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VISUAL AND KINESTHETIC SHORT-TERM MEMORY IN A FREE-MOVING-LOAD SYSTEM

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Visual and Kinesthetic Short-Term Memory in a Free-Moving-Load System," submitted by Victor Herbert Moyst in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

The purpose of this study was to discern which of the available sources of sensory input a performer attends to in perceptual motor tasks. In particular the areas of interest were an assessment of the relative importance of visual and kinesthetic short-term memory, an assessment of the retention accuracy of visual and kinesthetic short-term memory, and a determination of the effect which a change in ballistics pressure has on short-term memory. A free-moving-load system apparatus was constructed as a means of testing short-term memory.

The sample consisted of nine randomly selected right-handed college freshmen registered at the University of Alberta in 1968-1969. Each subject received the eighteen experimental conditions (five replications) in a random order. Thus, each subject had ninety trials.

The data was processed by ANOVA 80, a fortran IV program for an n way analysis of variance. From the results of the analysis performed on this data it was concluded that in a free-moving-load system visual retention is more accurate than kinesthetic retention in immediate, delayed, and delayed plus interpolated task conditions. It was also concluded that a change in ballistic pressure had no effect on the accuracy of short-term memory. It appeared that visual retention was more accurate than kinesthetic retention but within time limits of less than ten seconds both are highly accurate.

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CHAPTER I

INTRODUCTION

The fact that man as a processing performer operates on both environmental input (external) and information retrieved from memory (internal) is not a new concept. His ability to receive information at the sensory level depends largely on the present state of the sensory modal being impinged upon, and his selective attention towards that incoming information. His ability to recall and utilize material successfully depends principally upon at least two of his inherent memory systems; short and long-termed memory. For the purpose of this study, short-termed memory is the more important of the two as it allows the investigator to draw conclusions concerning the immediate state of the performer. In this respect, short-term memory can be considered to be that system within which material is maintained for brief intervals of time. The time span in short-term memory is generally considered to range from 0 to 60 seconds (71:267; 36:153; 75:81). An athlete must rely greatly on this swift feedback due to the rapidly changing situations of competition. Once a particular situation is concluded, sensory material produced by the situation disappears with the time span of short-term memory. This information is also displaced by more immediate information entering the system. The cycle of replacement and displacement is a continuous one.

A human information processor does not usually perform using only one sensory modality. In many situations auditory, kinesthetic, and visual sensations are used collectively to execute behaviour patterns. Psychologists (73, 72, 9:241) have concluded that information from

various sensory modalities could be processed and retained differently by the short-term memory system. If coaches and trainers wish to be thorough in the training process of individuals, then it is essential that they know what kind of information the performer utilizes. It is also important to know the etiology of the information. If it is possible to classify the type of information to which a performer attends, then the most efficient learning, coaching and performances can be achieved by stressing practice of the correct informational cues of the motor task. Physical educators, coaches, and trainers must at this time be content with secondary methods as the present state of the performer is not clear.

Although extensive research has been done in the past decade with respect to short-term memory, the bulk of it has been concerned with visual and verbal responses. Many psychologists (1, 3, 39, 40, 73) have investigated the response of short-term memory to motor performance. In order to identify the state of the performer exactly, the manner in which man reacts to the recall of visual, verbal, and motor tasks must be known. No longer is the mechanical analysis of a performer's physical attributes sufficient. Concentration must also be applied to the psychological state of the performer if the complete status of the individual is to emerge. At present this knowledge is limited and more extensive research is demanded.

The Problem:

The main problem is: To which of the available sources of sensory

input does a performer attend in perceptual-motor tasks. In particular, which type of information does a performer attend to in a motor task involving the acceleratory (ballistic) qualities of a skilled movement.

Sub-problems:

One sub-problem of the experiment is to assess the relative importance of both visual and kinesthetic short-term memory in tasks involving the acceleratory qualities of skilled movement. In addition, when both visual and kinesthetic cues are present it will be noted whether their effects on retention are additive. If this is the case, then more accurate recall can be expected when both factors are present. Finally, the problem of retention with and without an interpolated task will be reviewed. In this respect, the interest is whether both visually and kinesthetically stored short-term memory are retained equally and whether both are equally affected by an interpolated task.

Importance of the Study:

Efficient training in complex motor tasks requires concentration on both physical and psychological aspects. Assuming visual and kinesthetic memory to be important in psychological training, it would seem logical to emphasize the predominant factor in a particular phase of training. A more thorough understanding of visual and kinesthetic short-term memory would ensure the practice of more efficient and reliable coaching methods and athletic performances.

Limitations:

1. The study is limited by the statistical design utilized to analyze the results, and by the accuracy of the error scale used to measure the magnitude of the subject's replacement error.
2. The study is further limited by the fact that the task was not a serial continuous one.
3. The study is limited by the quantity of research done in the related area. Although a sufficient amount of work has been performed with respect to visual and verbal short-term memory, the status of motor short-term memory is still in its infancy.

Delimitations:

1. The study is delimited by the restriction of the area being observed. A free-moving load system (exemplifying ballistic movements) is typical of only one mode of physical movement. Thus, the results of this study are justifiably applicable to only this type of movement.
2. The study is delimited by the number and status of the subjects involved. Nine randomly selected subjects of the University of Alberta first year student population were used for the experiment.
3. The study is further delimited by the selection of only right-handed male freshmen as subjects.

Definition of Terms:

Kinesthesis: Kinesthesis is the position sense originated by receptors

located in the muscles, tendons, and joints. Through it the individual perceives bodily tension and movement on the basis of what he is doing in terms of their relation to some contemplated mode of behaviour (69:572). Adequate stimulus for activation of the receptors is the mechanical pressure and state of strain in the muscles, tendons, and joints resulting from bodily tensions brought about by body position.

Kinesthetic Sense: For the purpose of this study kinesthetic sense will be defined as that faculty enabling a subject, devoid of visual stimulation, to approximate the original position of the apparatus handle.

Free-moving-load System: A free-moving-load system may be considered to be one which necessitates initial inertia to place it in motion. However, once a system is in motion, no extra force is necessary to maintain the motion.

Short-term Memory: Short-term memory is that system capable of bringing the crank back to its original position. In this case, the short-term memory time span does not exceed sixty seconds.

Long-term Memory: Memory containing the same basic attributes as short-term memory but lasting longer than sixty seconds can be considered long-term memory.

Interpolated Task: A task occurring between the presentation of sensory material and the recall of the same material is an interpolated task.

Retroactive Inhibition: Retroactive inhibition occurs when a task placed between the presentation and recall of material is responsible for the degree of forgetting of the original material.

Measurement Error: In this experiment measurement error will represent the total number of absolute degrees by which a performer varies from the presented stimuli during crank replacement.

CHAPTER II

REVIEW OF THE LITERATURE

During the past decade short-term memory has become a prominent issue in psychological study. Prior to this period, experimenters were prone to refer to their studies as concerning memory measured over a certain length of time. Recently, psychologists have progressed to the stage of outlining the limits of both short-term and long-term memory. Melton (52:300) has concluded that short-term memory involves activity traces, autonomous decay, and a fixed capacity that is subject to overload and consequent loss of elements stored in it for non-associative reasons. In more general terms, Posner (73:267) defines short-term memory as the retention of new information over relatively brief periods of time. In this case, Posner suggests that the time span be from 0 to 60 seconds. Still with respect to the time span, Postman (77:145) states that, "the delimitation of 'short' in the phrase, short-term retention, is necessarily arbitrary ..... as in actual practice, retention intervals of the order of seconds or minutes are used." In addition, Postman (77:146) makes the distinction between short-term and immediate memory. Short-term memory can be measured in seconds or minutes but immediate memory occurs when a single presentation of learning materials is followed without delay by a test of performance. In this case, the measures of retention would define the amount of immediate memory. Postman (77:147) has concluded that the measurement of immediate memory span is by the number of discrete units that can be reproduced in correct serial order after a single exposure.

As a result of the recent interest in the area of short-term memory, many theories have been postulated regarding the mechanisms involved in forgetting. When these theories are viewed in totum two appear prominent: the decay theory and the interference theory. Decay theorists support the hypothesis that items are stored in the short-term memory system in trace patterns. Competition between various traces at the time of recall increases because the stored trace is weakened in the absence of rehearsal. The degree of forgetting is considered a function of the relative strength of the stored item at moment of recall. Postman (77:152) in his discussion of the decay theory postulated that the perception of each item leaves a distinct neural after-effect or trace. This trace is said to fade or decay gradually unless it is restored by repetition of the stimulus or by rehearsal. At any given moment in time, the probability of correct recall depends on the degree to which the decay of the trace has progressed. Interference theorists claim that competing items strengthen over a time interval due to spontaneous recovery. Posner and Konick (74:222) sum up forgetting in the two theories in the following statement: "Forgetting increases in time either because previous items which were inhibited at the moment of presentation of the new item recover increasingly over a retention interval or because for some reason other than interference the strength of the stored item decreases over the interval." The former mechanism is associated with interference while the latter would be more compatible with a decay theory. Broadbent (8) in his description of trace theory found that retention in short-term memory is subject to disruption through overloading alone and not through associative interference factors. Although psychologists would probably

[illegible]

agree that forgetting does indeed occur over short-term intervals, there is still a great deal of discrepancy with respect to the validity of the decay and the interference theories of forgetting.

With respect to memory experiments, Norman (61:370) has concluded that performance in a memory experiment can be attributed to the interactions among three different processes: the initial acquisition of the critical item, the retention of that item in memory, and the retrieval of the item from memory. Waugh and Norman (89) found that recall of an item depended on two things: the likelihood that it is still in a temporary memory system and the likelihood that it got into a longer-term memory system. Although these concepts are generally accepted, not all concepts concerning short-term memory are as unanimously agreed upon by psychologists.

Proactive inhibition, or interference with the recall of an item due to the effect of prior learning, is a highly controversial issue in short-term memory. Peterson and Peterson (66:194), using forty-eight consonant syllables with a Witmer Association Value of 33% or less, found little evidence to support the concept of proactive interference in short-term memory.

Keppel and Underwood (36:155) performed an experiment in which they divided forty-eight experimental items into successive blocks of twelve items each so that blocks one through four reflected increasing degrees of learning of the items to be recalled. Simultaneously, they increased the number of potentially interfering items. The percentage correct at recall by blocks was determined separately for two short intervals and two long intervals. From the results, the experimenters deduced that

proactive inhibition does occur but practice negates its effect. This enabled Keppel and Underwood to answer Peterson's query about why longer trials did not demonstrate the proportionate increase in correct responses that shorter trials did. In this case, Keppel and Underwood claimed that proactive inhibition effects had surpassed the initial practice effects.

Postman (77:169) has no qualifications with respect to his statements concerning proactive inhibition. He believes that it exists and, furthermore, that it has a noticeable effect on recall in short-term memory. In addition, he found that the amount of proactive inhibition increases with the length of the retention interval in cases between three and eighteen seconds. From his work, it was ascertained that the number of prior items which the subject has access to, interacts with the length of the interval (between stimulus and recall) to determine the amount of interference.

Loess and Waugh, from the results of their experiments (46:456), have clearly implied that there is some length of inter-trial interval below which proactive interference is exerted on a given item by its predecessors in a series and above which it is not. Proactive inhibition, therefore, appears to increase with the length of the retention interval. This finding is more highly qualified than Broadbent's theory (10:225) that forgetting in the absence of any intervening learning is largely due to proactive inhibition.

Wickens et al (94) and Keppel and Underwood (36) were interested in the effect which interpolated activity imparts on retention in short-term memory. From the results of experimentation, both groups were able

to infer that the effect of interpolated material on retention is highly dependent on the number of previous trials with similar items that the subject has had. This, in part, suggests that proactive inhibition does have an effect on retention.

From the previous studies it is evident that there are broad discrepancies concerning the effect which proactive inhibition has on short-term retention. Therefore, proactive inhibition and its effects will not be a major concern in this study.

Another concept of short-term memory, which is being disproven concurrently with this study, is the method in which subjects store material in short-term memory to facilitate recall. Prior to the past five years, all information recalled from short-term memory was generally believed to be stored in the form of verbal cues. However, more recent research has all but invalidated this theory.

Posner and Konick (75:71) conducted a series of experiments concerning the short-term retention of the position of a circle on a line (visual-location) and the length of a motor movement without visual feedback (kinesthetic-distance). The results of these experiments and actual questioning of the subjects led them to believe that primary retention of information is through imagery rather than verbal codes. Bilodeau et al (5), using a lever-positioning task in which changes in accuracy of reproduction could be assessed over time, arrived at basically the same conclusions as Posner and Konick. Adams and Dijkstra (1), using a similar device, obtained rapid forgetting for motor movements over unfilled retention intervals from 5 to 120 seconds. The degree of accuracy and the large amount of forgetting over a brief interval led these experimenters

to suggest that information was not stored in the form of verbal labels.

The group of psychologists advocating the verbal coding theory had performed their experiments basically in the area of visual and verbal retention. However, most of the support for visual imagery coding has resulted from experiments dealing with motor retention. It would appear that subjects store information in short-term memory by a method based on the type of task which they are performing.

The concept of equal processing for visual and kinesthetic information in short-term memory has recently been criticized. This is basically due to the efforts of two psychologists. Posner and Konick (75:71), in an experiment involving the position of a circle on a line (previously described), demonstrated that both visual and kinesthetic tasks showed forgetting of information over a time interval up to thirty seconds. They further realized that, in the presence of an interpolated task, visual retention decreased as a function of the increasing difficulty of the interpolated tasks. This was not the case for the kinesthetic task. In fact, the difficulty of the interpolated task had virtually no effect on the short-term retention of kinesthetic material. From the results of these experiments, Posner and Konick concluded that retention of information about visual location seems to require the availability of a central processing capacity but kinesthetic distance does not. In addition, in the same experiment, Posner and Konick determined that the percentage of loss from the visual image over the first ten seconds was about thirty-six percent while the kinesthetic image lost about fifty percent. Since the kinesthetic task seemed to lose as much information regardless of the interpolated task, the experimenters concluded that the visual image had

a greater storage capacity regardless of the degree of attention which can be given to it.

Not all theories of short-term memory are disputed as greatly as are proactive inhibition and coding. One concept which is generally accepted has been postulated by Broadbent (11:325). He concluded that when a subject has to make an appropriate response to any one of a number of possible signals, the speed with which he makes his choice depends upon the number of alternative responses and on the relative frequency with which each of them may be demanded. Still with respect to generally accepted theories, Bourne and Parker (7:58) noted that, in experiments involving the recall of certain types of lists, structured lists, whether systematically or unsystematically presented, were learned more efficiently than random lists. Coherent material or material with a high associative value seems to be easier to retain than material of low associative value. In summary, Posner and Konick (74:222) found that forgetting increased with task difficulty.

Interpolated Task and Delay Period

'Interpolated task' can be defined simply as any task placed between the presentation of sensory material and the recall of the same material. To achieve the true effect of the interpolated task, it is essential that the subject concentrate on it. Broadbent (10:220) has found that very rapid forgetting can be demonstrated in short-term memory, so that recall even of quantities of material less than the memory span may be imperfect quite soon after presentation. In order to produce such forgetting, he

advocated that the main essential was to make the memorizer indulge in some other activity following the presentation of the material to be remembered.

Waugh and Norman (89) noted that events immediately following stimulus presentation can have a marked effect on information retention. These events need not be interpreted as the answers but may simply have an interfering effect.

Posner and Konick (75:84) postulated a similar conclusion in an experiment using recording, adding, and classifying mathematical terms as interpolated activities. They also had one case in which a rest condition was placed between the presentation and recall of sensory material. They found that the recording task had as much visual and motor activity as the more difficult tasks and yet produced little or no forgetting of visual location. Similarly, the rest condition involved little or no movement but produced as much forgetting of kinesthetic distance as the various digit tasks. This led to the conclusion that the interpolated tasks exercised their effect by controlling the processing capacity available during the interval for processing the stored images.

Talland (87:149) concluded that the effect of the interpolated task must be assessed not simply in terms of rate or number of responses, but, for the load it imposes on the subject's capacity to handle information. He, moreover, advocated that the interpolated activity had a consequent disruptive effect on the subject's set to retain a message. The latter effect of the interpolated task arose because in his experiments, Talland found that the delay between the interpolated task and recall was longer with unsuccessful recall than with correct recall.

A question of importance has recently been answered by Wilberg (96). In an experiment measuring visual and kinesthetic memory with respect to torque on a replacement accuracy task, he found that the interpolated activity effected both visual and kinesthetic short-term memory.

Norman (61) reported a study of serial-position effect in recognition memory which he and Wickelgren had performed. They found that the forgetting of three-digit numbers in a short-term memory experiment could be described by the same exponential decay of memory trace which strengthens with the number of interfering items regardless of the length of the list. In an earlier experiment, Waugh and Norman (89) used the "probe digit" experiment to minimize the effects of long-term memory and response interference. Results of the "probe-digit" experiment were compared with the recall measures obtained by several experimenters in a variety of studies. When allowances had been made for response interference and long-term memory in these experiments there was reasonably good agreement between the experimental results. The observed rate of forgetting seemed to depend mainly upon the number of interfering items and was the same for all experiments regardless of the type of item involved or the rate of presentation.

Peterson and Peterson (65) conducted an experiment in which the retention of two pairs of words after intervals of four, eight, and sixteen seconds filled with counting backwards was observed. Correct recall was seen to decrease with a simultaneous increase in the time span and the interpolated activity. In an earlier study by the same experimenters (66), subjects counted backwards for varying periods of time after the presentation of a single trigram. They concluded that differences found in re-

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call may be due to the interference caused by the interpolated task. Shepherd and Teghtsoonian (82) also found that the probability of a correct response declined as a function of the number of intervening items.

Hellyer (32:650) performed an experiment in which he varied the number of repetitions of items before recall and used groups of three digits as neutral material to fill the retention interval. He concluded that there was an orderly progression of forgetting as the retention interval increased.

Studies, such as the preceding, led Postman (77:158) to theorize that, when activity other than rehearsal of correct responses fills the interval between stimulus presentation and recall, conditions of interference may be created which mask the normal development of the memory trace. Regardless of the explanation of the methodology behind forgetting, it is generally agreed that in studies of short-term memory an interpolated task causes forgetting.

Several studies have been carried out which deal with the effects of task rehearsal and the difficulty of the interpolated activity. Sanders (79) performed a study in which the amount of free rehearsal time, the amount of interference, and the time between presentation of the stimulus and a first recall were varied systematically. The discrepancy between his first recall and his second recall was taken as a measure of the interfering effect of the interpolated task. The effect of the interpolated task on forgetting decreased as the time allowed for rehearsal increased. Similarly, Peterson and Peterson (66) found that when rehearsal is permitted, the level of the retention curve is a function of the number of repetitions.

Conrad (16:47) required subjects to report a zero along with an eight digit message. He concluded the effects of interference were equal whether the zero had to be reported immediately after reception of the eight digits, or just prior to their recall following a ten second delay. This would seem to indicate that rehearsal had very little or no effect on retention.

Posner and Rossman (76) performed a study in which they held retention time constant and similarity of stimuli constant. With these restrictions, they found that varying the difficulty of the interpolated items greatly decreased short-term retention. In a more recent experiment, Posner and Konick (75:76) used recording, adding, and classification of mathematical material as interpolated tasks. Evidence for forgetting in the record condition was marginal while clear forgetting was shown in the more difficult addition and classification tasks. The latter case showed a greater quantitative increase of forgetting.

In general, the conclusions of previous experiments support the theory that rehearsal aids retention while an increase in the difficulty of the interpolated task decreases retention.

Similarity of interpolated items with the original material to be recalled is a topic which has been investigated recently. Peterson (64:198) studied this problem using a paired-associate situation. He found that it made very little difference whether the interpolated activity was similar to or dissimilar to the original material to be retained. In both cases, marked forgetting occurred. Similarly, Taylor et al (88:220) using a delayed alternation task found that the number of errors made by subjects increased when an irrelevant task was presented in the delay interval.

The number of errors increased with the number of items presented in the delay interval but neither the difficulty of the irrelevant task nor its similarity to the alternation task affected the number of errors. Thus, with respect to short-term retention, the similarity or dissimilarity of the interpolated task to the initial task has very little effect.

Several investigators have been interested in the effect which the length of the interval between presentation and recall has on retention in short-term memory. Johnke (34) used word lists of six, ten, and fifteen words in counterbalanced order and retention intervals of zero, three, nine and eighteen seconds. Short-term recall was seen to be inversely related to the length of the retention interval with the greater portion of forgetting occurring within three seconds.

Mortenson and Loess (54:797) tested retention of four, six, and eight digit messages after one and ten second intervals. The retention intervals were either unfilled or partially filled. Retention of four digit messages was essentially perfect under all conditions. Retention after one second was significantly reduced for six and eight digit messages if "0" was interpolated during the interval. Retention decreased as a function of time.

An experiment dealing with the effect which message length, length of retention period, and the repetition of message has on retention was performed by Talland (87:144). He noted that recall was inversely related to message length and less consistently, to the length of the retention period. Overt repetition of the message increased the probability of recall as did rehearsing the material to be remembered. Similarly, Postman (77:151) reports that the major variable determining the

memory span is the length of the time sequence preceding recall.

From the preceding experimental conclusions, it would appear that interpolated activity, difficulty of both initial and interpolated material, rehearsal, number of items in interpolated activity and time span of delay period all effect short-term retention. In most cases there is general agreement among psychologists as to the extent of this effect.

Visual and Verbal Short-term Retention

Intensive study concerning short-term memory has been done in both the visual and verbal categories. Unfortunately, this is not the case with motor tasks. However, many concepts can be applied with equal validity to all three areas. Thus, a good portion of research done in visual and verbal areas is not worthless if one is studying motor tasks.

McCormick (60:213) has done ample work with visual positioning movements. As a result of this experimentation, he concludes that, in situations where the eyes are used in executing positioning movements, the degree of visual control depends largely upon how the movement is terminated. In this respect it could be fixed either by mechanisms or by the individual.

With respect to studies of visual comparison search and memory search, Posner (73:270) has found that the former is greatly affected by visual confusability. However, a memory search task showed no effect of acoustic confusability and only a small effect of visual confusability.

The duration of the time span between presentation and recall of visual items seems to follow the basic pattern of most types of short-term

studies. Retention decreases as time span increases.

Mackworth (48:308) showed that for a visual presentation task, the interpolation of other material between reading and recall of a different material leads to forgetting of the first material. This experiment involved short-term retention periods. In addition, the amount of the primary material forgotten was in direct proportion to the duration of reading the interpolated material. Similarly, Peterson et al (68:402) using a memory drum to present visual stimuli found that the probability of recall of individual associations decreases steadily as a function both of the time interval and the number of items intervening.

Crawford et al (18) used a pattern of letters presented for less than one second, with retention interval varying from one to ten seconds and no intervening activity to study short-term retention over a given time period. From the results of this experiment, they were able to infer that greater accuracy of recall occurred at longer retention intervals (up to one minute). This is in contrast to the visual decline of accuracy which occurs when retention is measured over minutes or longer.

Peterson and Peterson (66) developed a technique whereby a single verbal item was presented to subjects for a learning trial of approximately one-half second duration with retention being measured up to eighteen seconds. No interpolated task was utilized in the experiment. The results were not in agreement with those of Crawford et al. The procedures used by Peterson and Peterson produced a very systematic relationship between length of the retention interval and percentage of items correct at recall. Seventy-eight percent retention occurred after three seconds while only eight percent occurred after eighteen seconds.

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Thus, forgetting of a single verbal item would appear to be almost complete after eighteen seconds.

As an extension of the same study, Peterson and Peterson (66) presented single consonant syllables of low association value and had the subjects count backwards for time intervals from three to eighteen seconds. They found that after eighteen seconds retention had declined to less than ten percent of the original.

Johnke (34:621) supports the theory that studies of delayed recall show marked primacy and little or no recency, regardless of whether the subject is instructed for serial or free recall. This is in direct contrast to immediate recall. Perhaps the order in which items are actually emitted in delayed recall is much the same following both free and serial recall instructions.

Posner (73) and Posner and Konick (75:71) have done a considerable quantity of experimentation investigating the effect on retention of increasing the difficulty of the interpolated task. In the former study, Posner found that visual location showed no forgetting at all if the subject was at rest, and rather dramatic increases in forgetting as the difficulty of the interpolated task increased. Posner and Konick tested subjects with respect to the position of a circle on a line (visual location) and the length of a motor movement without visual feedback (kinesthetic distance). Both tasks showed a systematic increase in forgetting over time. The visual location task showed a systematic increase in forgetting as interpolated task difficulty increased. However, retention of the kinesthetic-distance task seemed relatively unrelated to interpolated task difficulty. This finding led Posner and Konick to

suggest perhaps visual and kinesthetic memory were stored differently, with the former demanding some type of central processing.

Posner and Rossman (76) investigated the effect of interpolated task difficulty on the retention of simple verbal items. They held similarity of interpolated material and time in store constant. Their intent was to manipulate the portion of the subject's central capacity available for rehearsal by interpolating tasks of varying degrees of information reduction. These tasks all involved operation upon digit pairs. From the results, the experimenters concluded that the amount of forgetting was a direct function of interpolated task difficulty.

Pylyshyn (78:280) conducted a study using the recall of visually presented letters. He found that maximum decrease in recall score occurred when the interpolated task was placed directly after presentation of the stimulus to be recalled. The decrement in recall performance was slight when compared with recall without interpolated activity. This result varies from that normally found. Pylyshyn postulated that the small decrement occurred because the subjects were regularly expecting the interpolated activity.

Brown (12:20) and Cohen and Johansson (15:142) investigated experiments dealing with two of the more general concepts of short-term retention. Brown found that in the recall of digits similarity of the intervening task did not produce significant differences in forgetting. Cohen and Johansson concluded that the previous occurrence of a nine-digit number did not aid in its recall at a later presentation.

Controversy has arisen concerning the fixed qualities of the temporary memory system. Experiments conducted by Sperling (84) and Averbach

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and Coriell (2) have, by the nature of their results, supported a similar hypothesis. These results have allowed the experimenters to formulate the theory that the visual perceptual system contains a temporary memory or storage quality that has a time duration of something less than one-half second. Contrary to this finding is one concluded by Erickson and Steffy (24). They claimed that the system was not fixed but, rather, was controlled under the strict influence of interference factors.

The concept of a memory system being basically fixed would, if valid, be invaluable information to the trainer of human individuals. In fact, if the fixed length were known, it would provide the basis for the greater part of our training programs. One would know, by convention alone, exactly when, where, and how much information to put into the system. Unfortunately, the evidence is not sufficient at this time either to accept or reject the theory that a fixed memory system exists.

Kinesthesis and Kinesthetic Short-Term Memory

Many definitions of kinesthesis (33, 69, 95) have been proposed. In various ways these definitions support one particular aspect of the phenomenon or another. However, there are some common concepts inherent in each definition. Basically, the greater portion of the definitions support the theory that kinesthesis is a type of memory system controlled by receptors positioned in the muscles, tendons, and joints. In addition, few psychologists would reject Henry's theory (33) that kinesthesis (the muscle sense) represents one of the most vital areas for research in physical education. Laszlo (42:8) has arrived at another generally

acceptable theory. In her experiments she initiated the loss of kinesthetic sense by nerve compression locks. She then had her subjects perform a motor task of key tapping. Laszlo concluded that the loss of kinesthetic sensation greatly impeded motor performance. Thus, the kinesthetic information available to a performer is quite important with respect to the degree of performance possible.

One wonders what type of movements can be utilized to test kinesthesis. This question was partially answered by Witte (98:480) and Wiebe (95:229). They noted in their respective experiments, that arm positioning tasks were reliable measures of kinesthetic sense. However, they did not make the specificity of this sense clear. Observers of the experimental report would not know if 'kinesthetic sense' was specified to include only kinesthetic awareness of arm-positioning movements or did it include a general kinesthetic sense.

One controversy which has been debated to some extent deals with the specificity of kinesthesis. Is kinesthesis a simple factor which is highly specific or is it a complex one? Henry (33:176) has postulated that it is altogether possible that kinesthesis is a complex rather than a unitary phenomenon. He further advocated that perhaps kinesthesis involves several functions relatively unrelated insofar as individual variations are concerned.

Young (100:279) tested the effects of kinesthesis as it pertained to various body positioning tasks. She found that there was no correlation between arm positioning tests and the accuracy of throwing or hitting a ball. Low positive correlations were found between leg positioning tasks and the kicking of a target. In fact, no important relation,

positive or negative, was found between general motor ability scores and the kinesthesis tests. Young concluded that kinesthesis was highly specified. Similarly, Phillips (69:586) found no justification for use of the phrase "general kinesthetic sensitivity and control" unless reference is made to the sum total of many specific abilities. His tests involved putting and driving golf balls. From the results of these tests, Phillips concluded that kinesthesis is quite specific to the stimulus patterns involved in the tests.

Kinesthetic short-term retention seems to follow the basic patterns already observed in short-term memory. Adams and Dijkstra (1:317), using a simple positioning movement of a slide, found that the short-term retention of a simple motor task was in agreement with that of verbal short-term retention determined by Peterson and Peterson (66). It appeared that the accuracy of short-term motor recall was a decreasing function of the time measured in seconds. They noticed that the negatively accelerated retention curves were approximately of the same form as those for verbal responses. The main difference occurred because error and not probability of correct recall was the criterion of measure. This caused the slopes of the graphed experimental results to be opposite. In the same study, Adams and Dijkstra noted that, in a sufficiently large range, short-term recall was a positive function of the number of reinforcements.

Kinesthetic short-term retention differs from visual and verbal retention with respect to the increasing difficulty of the interpolated task. As discussed earlier, visual and verbal retention decreased as the difficulty of the interpolated task increased. This does not appear to be the case with kinesthetic retention. Taylor et al (88:220) found

that, in a delayed alternation task, the number of errors made by human subjects increased when an irrelevant task was presented in the delay interval. The number of errors increased with the number of items presented in the delay interval, but neither difficulty of the irrelevant task not its similarity to the alternation task was found to effect the number of errors.

Posner (73:273) found a decrease in retention in a kinesthetic-distance task even when the subject did nothing during the interpolated interval. Moreover, the rate of forgetting was completely independent of the complexity of the information processing interpolated between presentation and recall. Wilberg (96) concluded that non-verbal information entering short-term memory through a kinesthetic system appears to decay rapidly in the first few seconds as does visual material. Towards the end of a ten second delay period, before recall, and in the absence of sustained attention, the rate of decay slows so that the remaining information is equal to or better than that which can be loaded visually.

Broadbent (9:241) added his support to the theory that retention which arises from kinesthetic sensations is superior to that which arises from visual or verbal ones. In comparing sensory material and sequence of movement, he found that the latter were possibly less appropriate to a recurrent circuit mechanism. From the results of his experiments, he observed that there were less conscious reports of rehearsal in bodily skills than in learning involving sequences of stimuli. In addition, he concluded that the short-term retention of bodily skills should be less affected by factors interrupting rehearsal than is visual or verbal

retention. Therefore, forgetting should be slower and retroactive inhibition should have less effect in motor skills.

Recently, there has been considerable interest (as previously mentioned) in the manner in which kinesthetic and motor tasks are retained. This is especially true with respect to the interest shown in the comparison of motor retention as opposed to the verbal labels of visual and verbal retention.

Boulter (6), using a blind lever positioning task and verbal subject questioning, found that motor movement tasks must be maintained through imagery rather than exclusively by verbal labels. Adams and Dijkstra (1), using similar equipment, arrived at basically the same conclusions.

For a considerable time, there was a great deal of controversy concerning the interaction and importance of visual and kinesthetic information in replacement tasks. Posner and Konick (75:77) found visual information to be more important than kinesthetic in tasks of the replacement type. In fact, if both visual and kinesthetic information were available to a performer, the effect of the latter would be negligible. The sensory system would rely completely on vision.

In matters of short-term memory, there still remain many discrepancies. However, as outlined in the study, several aspects of the system are no longer contested. Basically, short-term verbal and visual retention is decreased by the length of the delay interval, the number of interfering items, and the difficulty of the interfering items. The latter condition does not appear to be applicable to motor tasks. Short-term retention in all areas is increased by rehearsal of the original task. In addition, material is stored in short-term memory systems by

both visual and verbal labels. Kinesthetic memory retains information more efficiently than does visual memory in the absence of rehearsal. It appears also to be the case that visual memory takes precedence over kinesthetic memory when both are available to the human information processor. The effects resulting from the length of delay interval, the presence of interfering items, sensory modality and the ballistics quality of the apparatus will be investigated in this study.

CHAPTER III

METHODS AND PROCEDURES

Sample

Nine undergraduate males registered in their freshman year at the University of Alberta, during the 1968-1969 academic session, constituted the sample. These subjects were selected from a required freshman physical education course. The only criterion of selection was right-handedness. In addition, the students were asked if they would volunteer to participate in the study. Each subject received the eighteen possible treatments of the experimental design. Each of these treatments consisted of five replications. The order of presentation of the eighteen treatments to the nine subjects was completely random.

Task

The task consisted of the simple replacement accuracy of a crank to a previously specified position. The accuracy of replacement was tested under visual and kinesthetic conditions.

The Apparatus and a Description of its Use

The apparatus was constructed in the manner illustrated (see Figs. 1 and 2).

The system consists of a central mandril on one end of which was placed a crank while on the other end was positioned a threaded rod to

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

FIG. A VIEW FROM BACK OF APPARATUS SHOWING ERROR SCALE, FRICTION CLUTCH SYSTEM, DEXION FRAME AND ELECTRICAL COMPONENTS

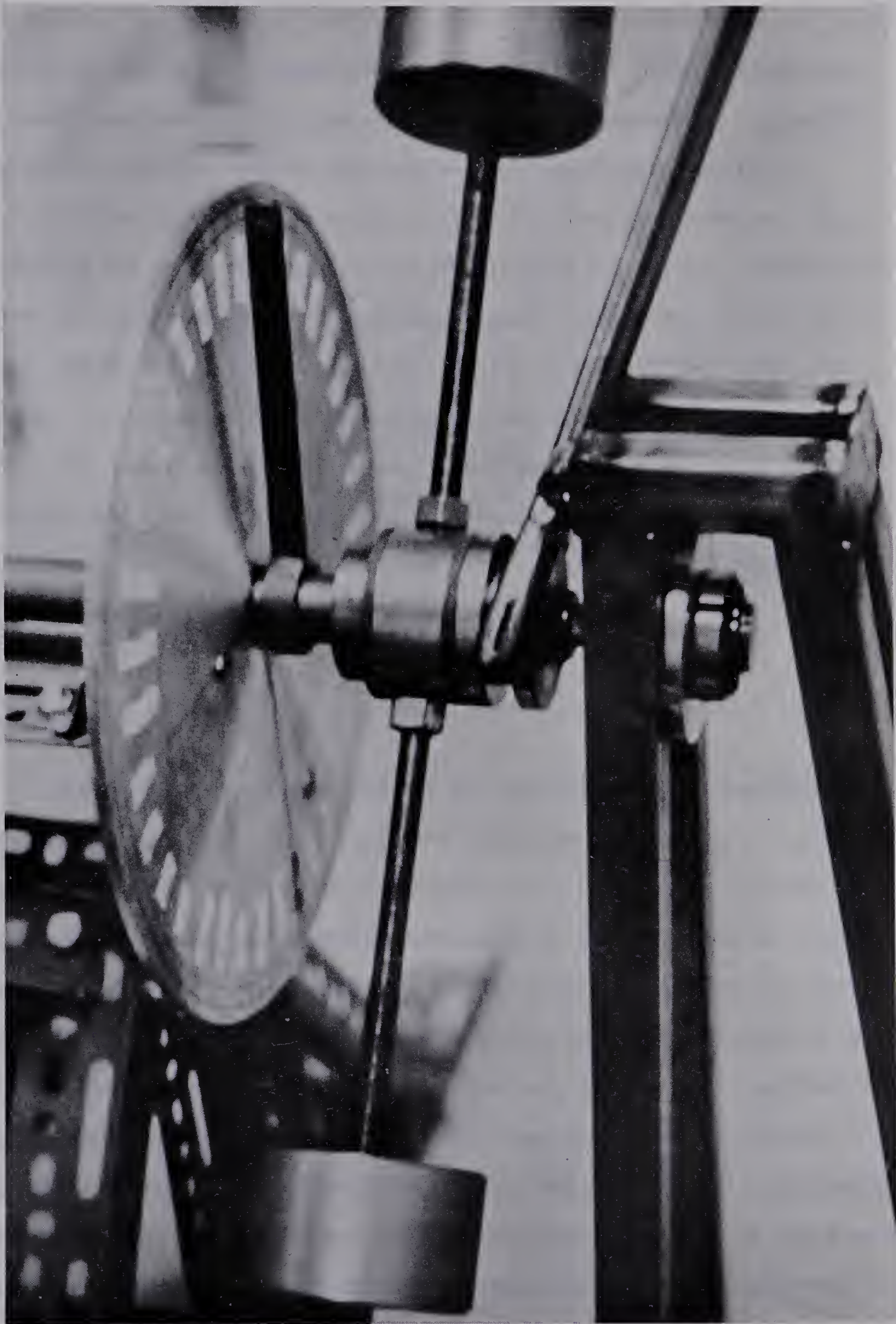


FIG. B CLOSE-UP VIEW OF FRICTION CLUTCH SYSTEM, WEIGHTED RODS, ERROR SCALE AND POINTER

which two tapped five pound weights were attached. These weights were placed individually on either side of the central mandril. The weights were spun onto the rod so that they balanced each other precisely.

A clutch was inserted in the system such that when released, the weighted rod would continue to spin freely from the crank. Consequently, when the subject received an auditory signal to stop, he had only to arrest the motion of the crank. Prior to the release of the clutch, the system was intact with a complimentary situation existing between subject and apparatus. In this case, 'complimentary system' meant that the subject drove the apparatus which in turn drove him by its impetus. The apparatus, with the exception of the crank, was completely concealed from the subject by means of a black screen.

Error Scale

A circular error scale (Fig. 2) was positioned at the experimenter's end of the apparatus. This scale had a hole bored directly in its center through which the central mandril could pass. In addition, the error scale was fastened to the dexion crib on which the apparatus was mounted. The crib prevented circular motion of the scale. Attached to the central mandril, and in close proximity to the scale, was a metal pointer (Fig. 2). This pointer was fastened parallel to the long axis of the crank and at the opposite end of the central mandril. The crank and the pointer turned in unison. The scale consisted of a 360 degree circle of diameter twelve inches. This scale was divided into equal intervals of one degree width. The error scale was further divided into four equal quadrants of

ninety degree width. The positions on the scale to be recalled were selected randomly from each of these quadrants.

Stimulus

An E.I.C.O. Model 337 auditory tone generator set at 400 c.p.s. (Band B) and forty decibels was used as the 'warning', 'start', and 'stop' signals. The tone generator with its connecting Bogen amplifier and four inch speaker were operated by a micro switch attached to the error scale. A signal was presented by the manual manipulation of the micro switch.

Error Measurement

In this experiment error consisted of the number of absolute degrees between the initial crank position and the subject's replacement recall.

Procedure

The subjects were individually instructed in the nature of the task, and were allowed to ask questions regarding the experimental conditions. Each subject was provided with a thirty minute practice session to ensure he understood completely the task requirements. During this practice session all experimental conditions were presented to the subjects. Throughout the experiment the subjects were instructed to turn the crank in accordance with a time pattern set by a metronome (Franz model - 76 beats per minute). When the subjects had achieved the time pattern of the

metronome they received the sound stimulus. At this point, they arrested the cranking action and positioned the handle. They then released the handle, turned 180 degrees, and performed according to prior instructions. The final task for the subjects was to replace the apparatus handle in the recalled positioned.

Instructions to the Subjects

The subjects were taught to react to selected verbal stimuli. In all three conditions of recall the initial verbal stimulus which they received was identical. Initially the word 'turn' was presented to the subjects. When a subject received this stimulus, he turned 180 degrees so that he was facing a table directly opposite the apparatus. After completing the turning movement the subject was instructed to respond to one of three verbal stimuli. He was either presented with 'recall', 'delay', or 'interpolate'. During the practice session he was informed that these stimuli meant to recall immediately, delay ten seconds and then recall, or perform the interpolated task for ten seconds before recalling respectively.

Independent Variables

The three independent variables chosen for investigation in this study were short-term memory, inertial characteristics of the task instrument, and sensory modality. The levels of each of these variables are as follows:

1. Short-term memory was divided into three temporal categories: immediate recall, delayed recall (ten seconds), and delayed recall (ten seconds) plus an interpolated task. This made it possible to measure the effect of time and an interpolated task on retention of a perceptual motor skill.

2. The inertial quality was also subdivided into three load categories: low, medium, and high. These divisions were effected by moving the weights to selected positions on the rod. Low, medium, and high were represented by placing the weights 1.5, 3.0, and 6.0 inches respectively from the central mandril.

3. The third independent variable, sensory modality, was divided into two categories: visual and kinesthetic.

Experimental Design

A factorial complete block treatment by subjects designed with repeated measures on all factors replicated five times was used for the experiment. This had many advantages for an experiment of the type which contains a great number of possible interactions between variables. The treatment by subjects design delegated individual differences to a minimum role and enabled a small number of subjects to be used. The complete block and factorial design assured that all eighteen treatment combinations of the variables will be tested.

	I		D		D+I	
	V	K	V	K	V	K
	|	|	|	|	|	|
Lo*	-	-	-	-	-	-
M	-	-	-	-	-	-
H	-	-	-	-	-	-

* Units Log 2 - one unit 1.5 x 5 lbs.

Statistical Analysis

The experimental design selected was matched to a three way analysis of variance. All resulting Fs were rejected at = .01. When an interaction appeared significant, it was followed by a test on means for primary main effects. This test on means and those applied to the main effects became the basis for the formation of *post hoc* hypotheses. The test on means used for all orthogonal *pre hoc* and comparison-wise *post hoc* means was the Duncan's New Multiple Range Test. All data were key punched onto IBM data cards, verified, and then run on an IBM 360 O/S using a modified Version II SSP routine.

CHAPTER IV

ANALYSIS

Hypothesis

As a result of the review of literature three original hypotheses concerning short-term memory, sensory modality and ballistics quality respectively were formed. These are expressed symbolically as follows:

H_1: $I = D < D + INT.$

H_2: $V < K$ except when $V + K$ are delayed with interpolated task

H_3: $Lo = Med = Hi$

No significant difference was expected in the accurateness of recall between immediate and delayed recall. However, a significant difference ($\alpha = .01$) was expected between either immediate or delayed recall and delayed recall plus an interpolated task. The second hypothesis was formed after reviewing Posner's study (75) where visual retention was generally more accurate than kinesthetic retention except when the retention periods were delayed and contained an interpolated task. In the latter situation the reverse condition occurred with kinesthetic retention actually being superior to visual retention. As stated previously, the third hypothesis was formed concerning the ballistics quality of the free-moving-load system. In this respect no significant difference in accuracy of recall was expected. Therefore, the hypothesis stated that the three qualities (low, medium, and high) were equal with respect to the degree which they affected short-term retention.

Results

A three way analysis of variance was performed on the main effects. The results of the analysis are found in Table 1.

Table 1

THREE WAY ANALYSIS OF VARIANCE-SUMMARY
ALL SCORES

Source	Sums of Squares	df	Mean Squares	F
STM#	7,947.2695	2	3,973.6348	43.7488**
BQ#	88.6988	2	44.3494	.4883
BQ X STM	225.0790	4	56.2698	.6195
Mod#	3,652.3455	1	3,652.3455	40.2114**
STM X Mod	643.1135	2	321.5566	3.5403*
BQ X Mod	86.6099	2	43.3049	.4768
STM X BQ X Mod	97.6420	4	24.4105	.2688
Error	71,936.1870	792	90.8286	

CRITICAL F VALUES

df	.05	.01	.001
2,792	3.01	4.64	6.97
4,792	2.39	3.35	4.67
1,792	3.86	6.68	10.95

* Significant at .05 level

** Significant at .01 level

\# Legend

STM = Short-term memory

BQ = Ballistics quality

Mod = Modality

A statistical significance was found between the three levels of short-term memory. The resulting F ratio was 43.75 ($p < .01$). Statistical significance was also found between the two levels of sensory modality. In this case the F ratio was 40.21 ($p < .01$). No statistical significance was found between the three levels of ballistics quality at either the .05 or .01 levels of confidence.

In the three way analysis of variance only the interaction between short-term memory and sensory modality was significant ($p < .05$). However, prior to the experiment a decision was reached to analyze only those F ratios significant at the .01 level of confidence. The quantities significant at smaller levels of confidence were simply to be reported.

A *post hoc* test on means was performed. This test was the Duncan's New Multiple Range Test. It was necessary to subject the means of those variables to the test in order to discern exactly where the significant difference arose. For the purpose of validation a similar test was given to the three levels of ballistics quality which were supposedly not significant. The results of the Duncan's New Multiple Range Test are contained in Tables 11, 111, and 1V.

Subjects and Replications

A five way analysis of variance was performed merely for diagnostic purposes with respect to subjects and replications. Excerpts were taken from this analysis (Table V) illustrating the F ratios for subjects ($F = 4.64$), replications ($F = 1.72$), and subjects times replications ($F = 1.17$). Only the F ratio for subjects was significant at the

Table 11

DUNCAN'S NEW MULTIPLE RANGE TEST
APPLIED TO THE DIFFERENCE BETWEEN K = 3 MEANS
(SHORT-TERM MEMORY - MAIN EFFECTS)

Means	3.95 I	7.33 D	11.60 I + D	Shortest significant R
3.95		3.38*	7.65*	$R_2 = 2.11$
7.33			4.27*	$R_3 = 2.20$
11.60				

* Significant at the .01 level of confidence.

Table 111

DUNCAN'S NEW MULTIPLE RANGE TEST APPLIED TO
THE DIFFERENCE BETWEEN K = 3 MEANS
(BALLISTICS QUALITY - MAIN EFFECTS)

Means	7.32 Lo	7.39 Med	8.09 Hi	Shortest significant R
7.32		.07	.77	$R_2 = 2.11$
7.39			.70	$R_3 = 2.20$
8.09				

No statistical significance was found at either the .05 or .01 levels of confidence.

Table 1V

DUNCAN'S NEW MULTIPLE RANGE TEST APPLIED TO THE DIFFERENCE BETWEEN K = 2 MEANS (SENSORY MODALITY - MAIN EFFECTS)

Means	5.50 V	9.75 K	Shortest significant R
5.50		4.25*	$R_2 = 1.7249$
9.75			

* Significant at .01 level of confidence.

Table V

EXCERPTS FROM FIVE WAY ANALYSIS OF VARIANCE SHOWING F RATIOS OF SUBJECTS AND REPLICATIONS

Source	Sums of Squares	df	Mean Squares	F ratios	Probability
S#	3,308.9207	8	413.6150	4.6365	0.00006
Reps#	613.8716	4	153.4679	1.7203	0.26131
S X Reps	3,337.3469	32	104.2921	1.1691	0.26717
Error	11,418	128	89.2088		

CRITICAL F VALUES

df	.05	.01	.001
8,128	2.01	2.65	3.27
4,128	2.44	3.47	4.62
32,128	1.54	1.83	2.05

* Significant at .01 level of confidence

Legend

S = Subjects
Reps = Replications

.01 level of confidence. A further test of intercomparisons was done for subjects and replications. The results of this test are contained in Table Vl. From the table it is apparent that no significant difference exists for either subjects or replications. Therefore, there was no significant difference between the subjects. Furthermore, all subjects appeared to treat all replications similarly.

Table Vl

INTERCOMPARISONS FOR SUBJECTS AND REPLICATIONS FROM FIVE WAY ANALYSIS OF VARIANCE

Source	df	Calculated F	Critical F*
STM vs Reps	2,4	.0225	18.00
BQ vs Reps	2,4	2.0115	18.00
Mod vs Reps	1,4	.0244	21.20
Reps vs S	8,4	.2157	14.80
S vs STM	2,8	.0225	8.65
S vs BQ	2,8	2.0115	8.65
S vs Mod	1,8	.0244	11.26
S vs Reps	4,8	.5813	7.01

* There is no significance at either the .01 or the .05 levels of confidence.

The results of the 18 experimental conditions were placed onto IBM data cards, verified, then submitted for computation in accordance with the input directions specified in a SSP routine for use on an IBM 360/57 computer (see Appendix A).

The means of the 18 experimental conditions are presented in Table Vll. Each mean is representative of forty-five scores. The means

Table V11

MEANS OF THE EIGHTEEN EXPERIMENTAL CONDITIONS

Condition	Mean	Condition	Mean	Condition	Mean
16	3.16*	12	3.42	01	4.62
18	4.28	08	4.86	14	10.11
05	8.33	09	8.64	06	16.96
13	2.64	17	5.62	15	4.24
02	5.11	11	9.93	03	9.71
10	9.11	07	13.51	04	13.09

* Measured in absolute degrees.

Table V111

MAIN EFFECTS MEANS (3 X 3 X 2 FACTORIAL DESIGN)

Short-term memory		Ballistics quality			
Immediate recall	3.95*	1.5" X 5 lbs.	7.39	Visual	5.50
Delayed recall	7.33	3.0" X 5 lbs.	8.09	Kinesthetic	9.75
Delay + interpolated recall	11.60	6.0" X 5 lbs.	7.32		

* Measured in absolute degrees.

represent the average replacement error (in absolute degrees) for the 18 experimental conditions. As stated previously the order of presentation to the computer can be found in Appendix A.

The means of main effects for the 3 X 3 X 2 factorial design are presented in Table V11. Each of the means for short-term memory and ballistics quality are representative of 270 individual replacement error scores (measured in absolute degrees). Each of the two means of modality represent 405 replacement error scores.

The main effects means follow the trend expected from the review of literature (1, 5, 48, 66, 75). The mean for immediate recall (3.95) is significantly less than the mean for delayed recall (7.33). In turn both means are significantly different than the mean for the delayed plus an interpolated task condition (11.60). Therefore short-term memory decayed over time and was considerably disrupted when rehearsal was not allowed.

The three means for ballistics quality were of exactly the ratio and proportion hypothesized in null hypothesis number three. There was no significant difference found between any of these means.

The two means for sensory modality were significantly different. This is in accordance with hypothesis number two which stated that visual retention was more accurate than kinesthetic retention.

The means for ballistics quality, short-term memory and sensory modality are represented respectively in Figures 1, 2, and 3. These figures each contain two graphic representations. The top graphs are composed of all condition means which collectively represent the factor illustrated. For both ballistics quality and short-term memory six

FIGURE 1

BALLISTICS QUALITY v.s MEAN ERROR

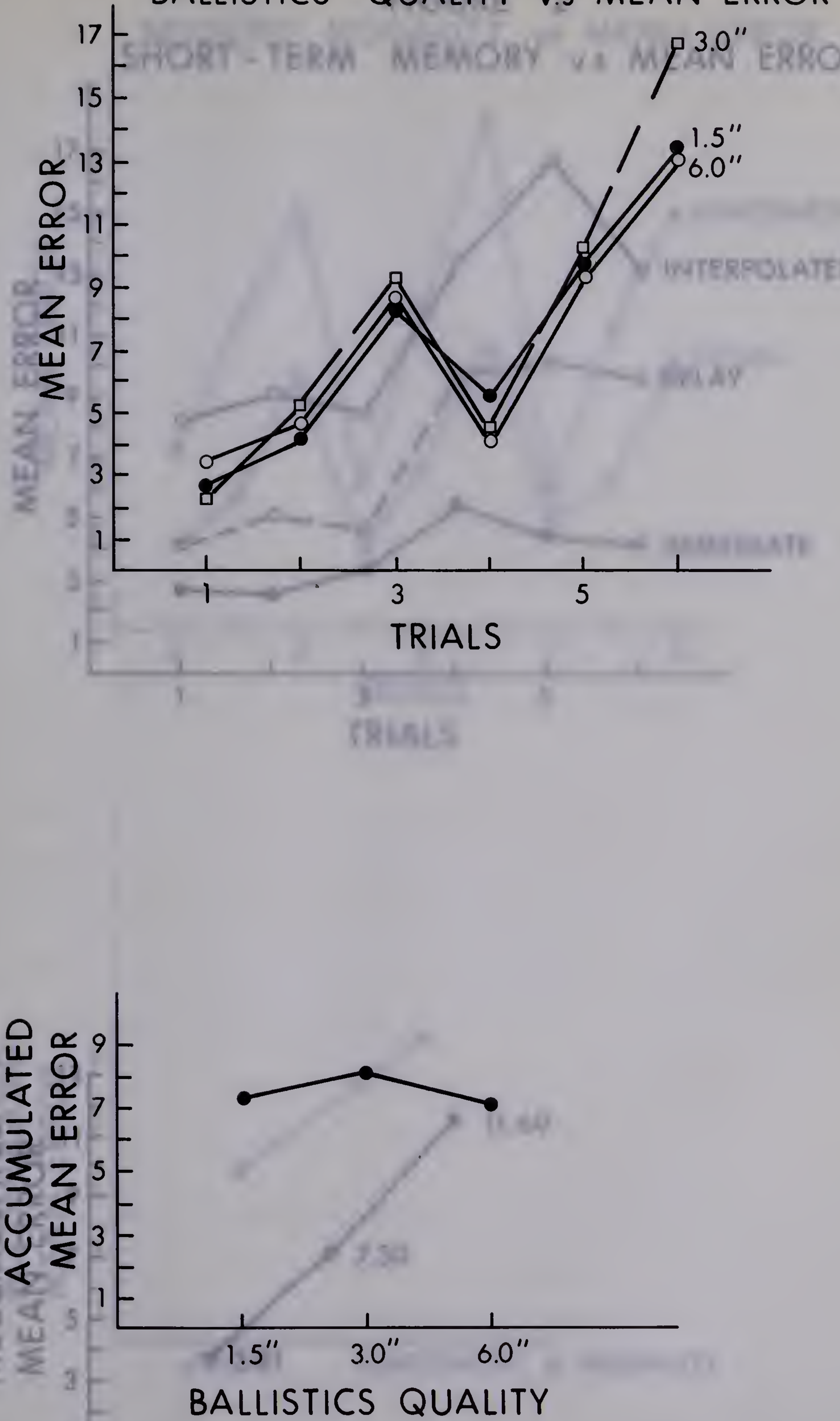
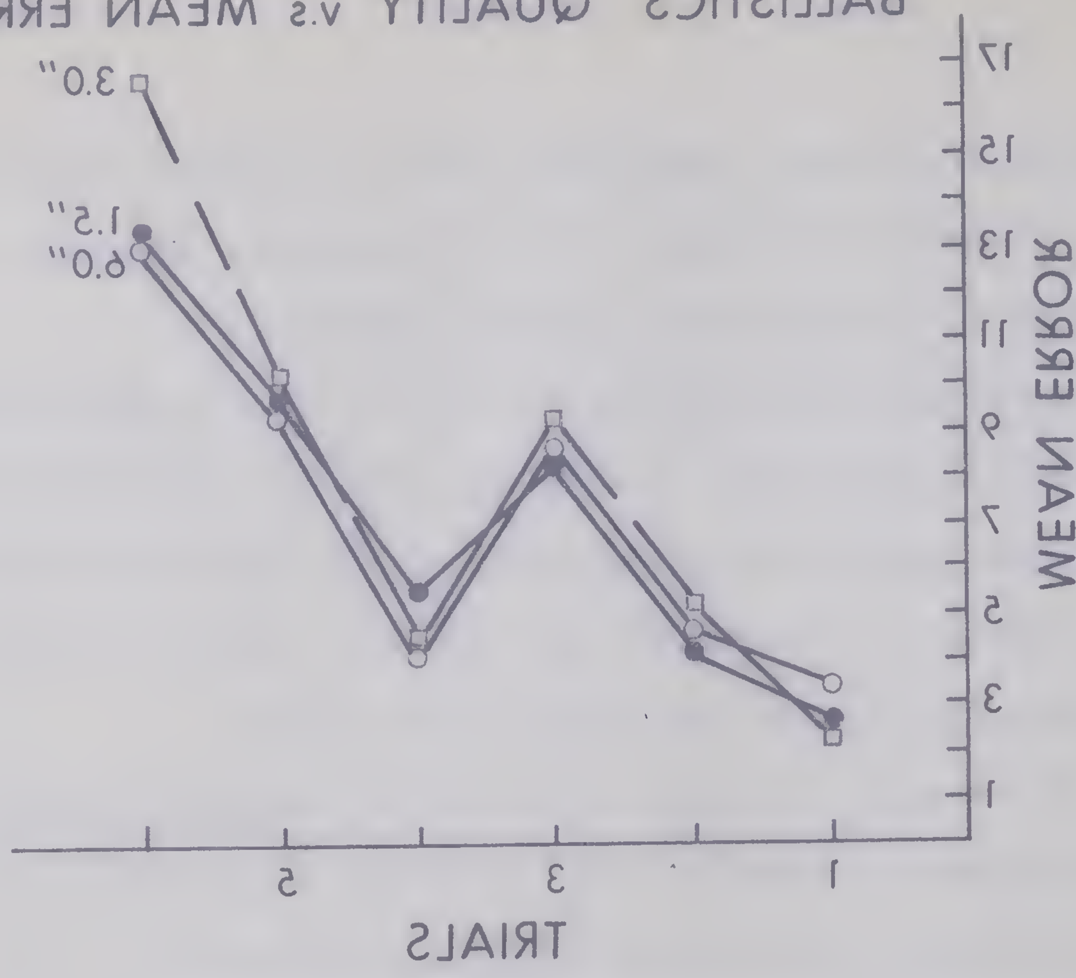


FIGURE 1

BALLISTICS QUALITY v.s MEAN ERROR



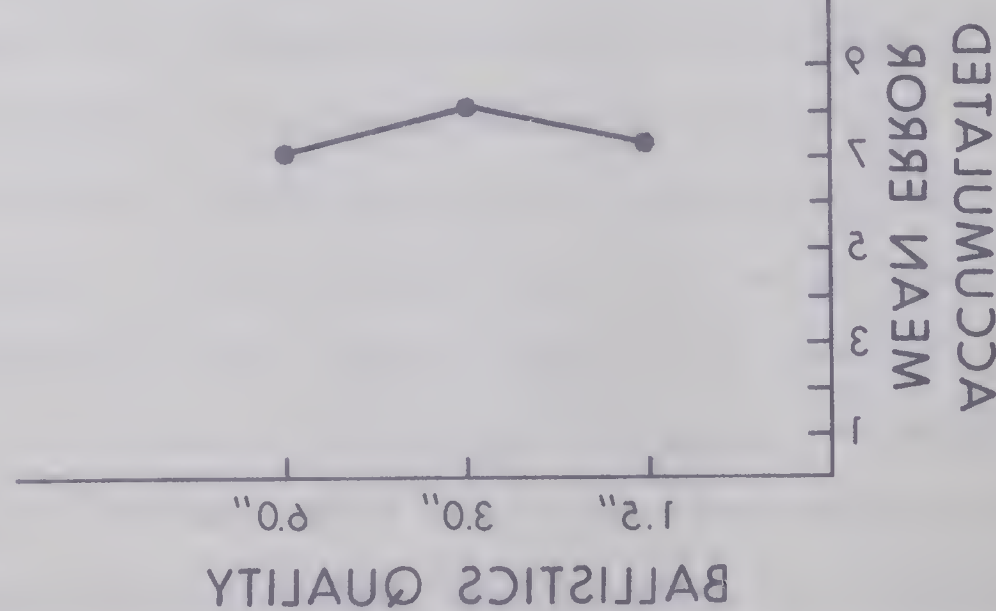
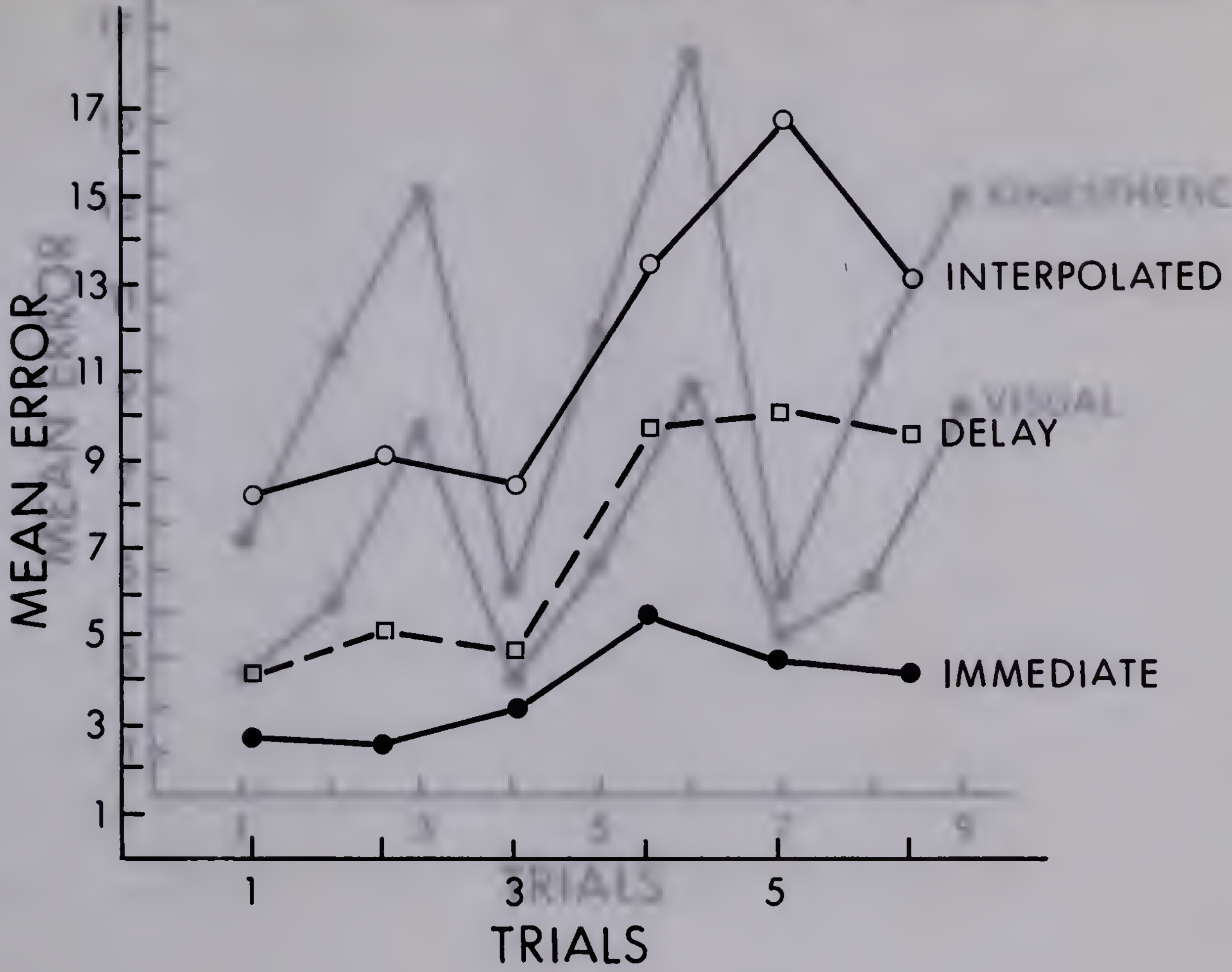


FIGURE 2

SHORT - TERM MEMORY v.s MEAN ERROR



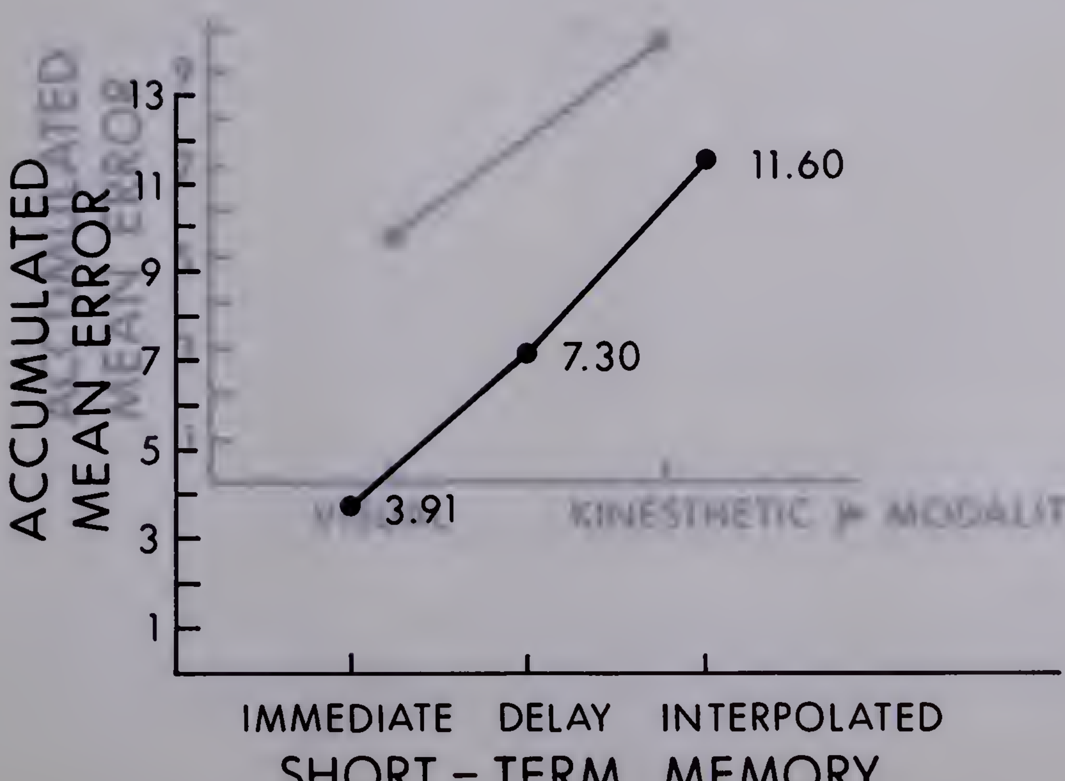
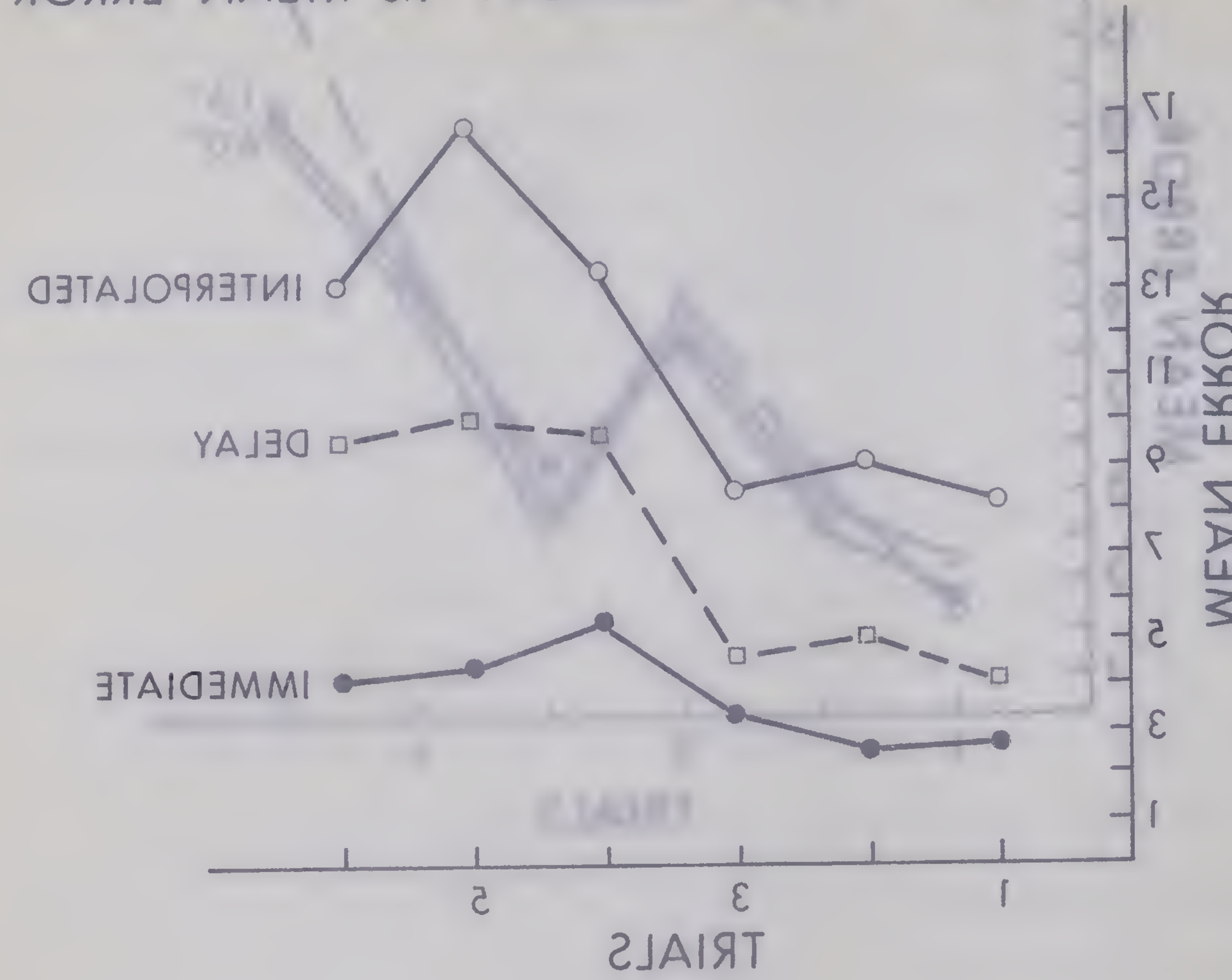


FIGURE 2

SHORT-TERM MEMORY v.s MEAN ERROR



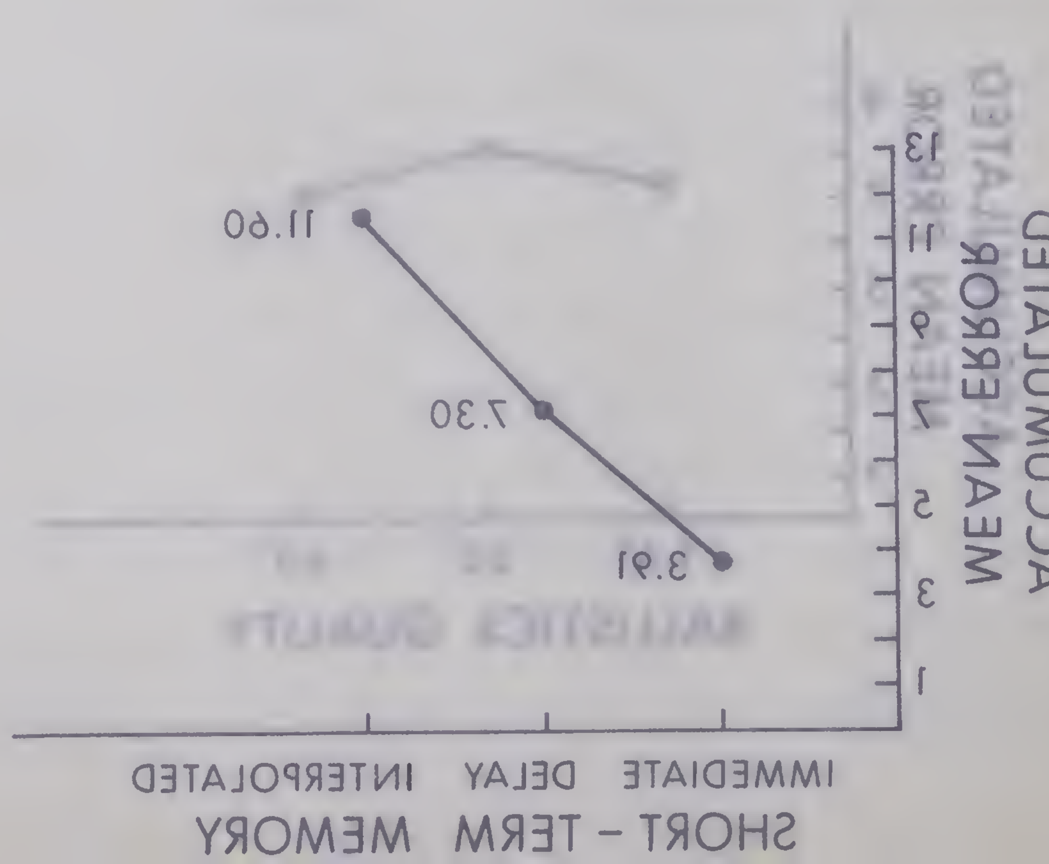
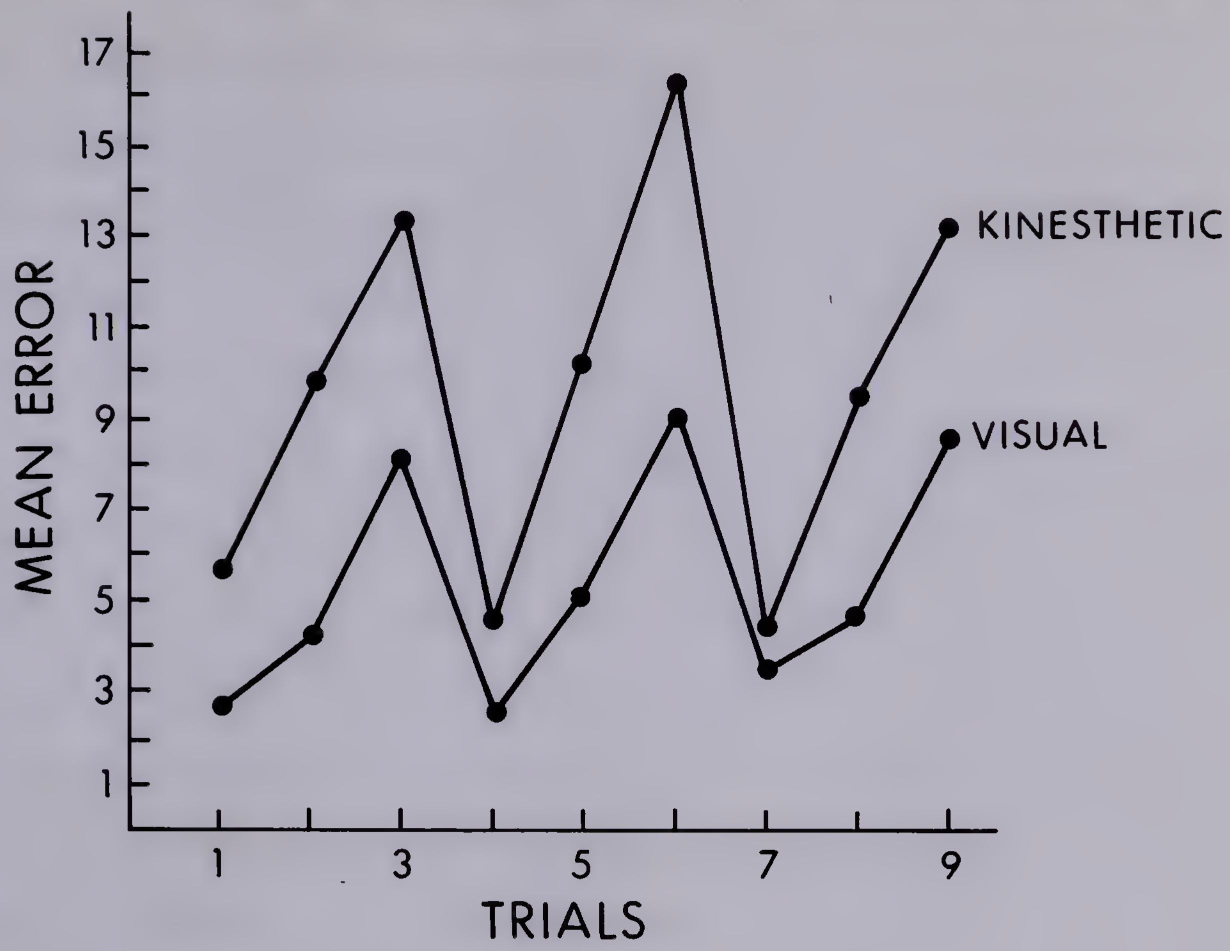


FIGURE 3

SENSORY MODALITY vs MEAN ERROR



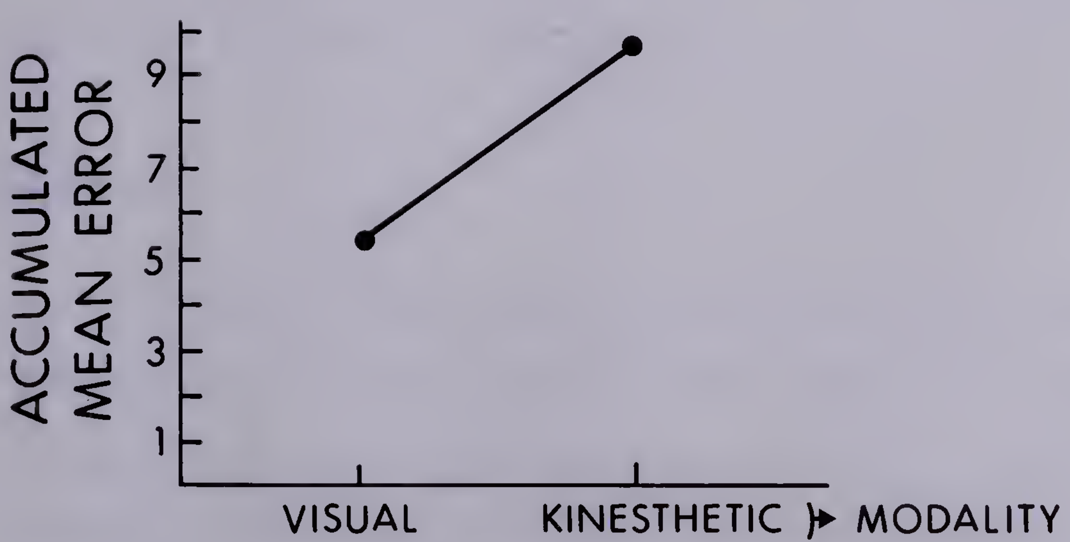
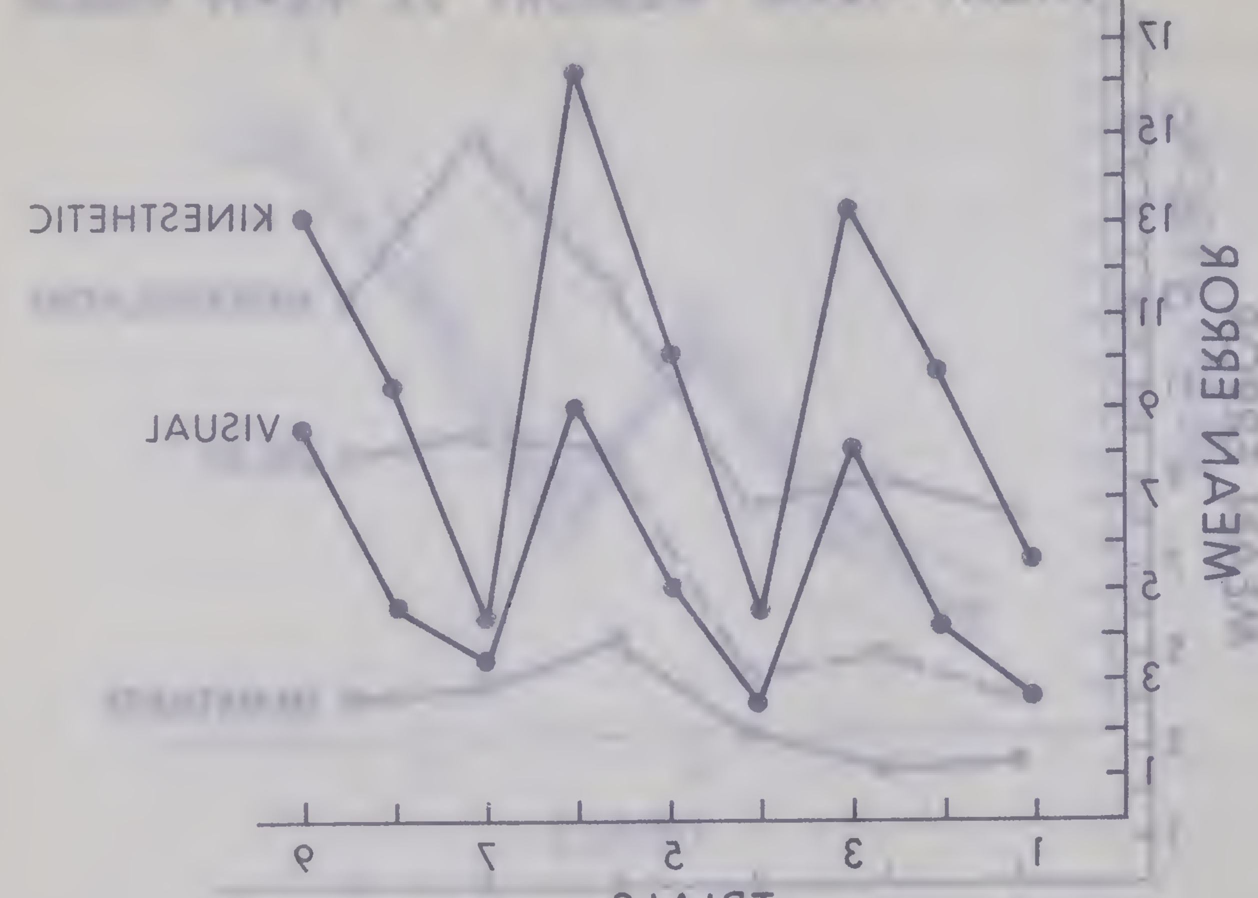
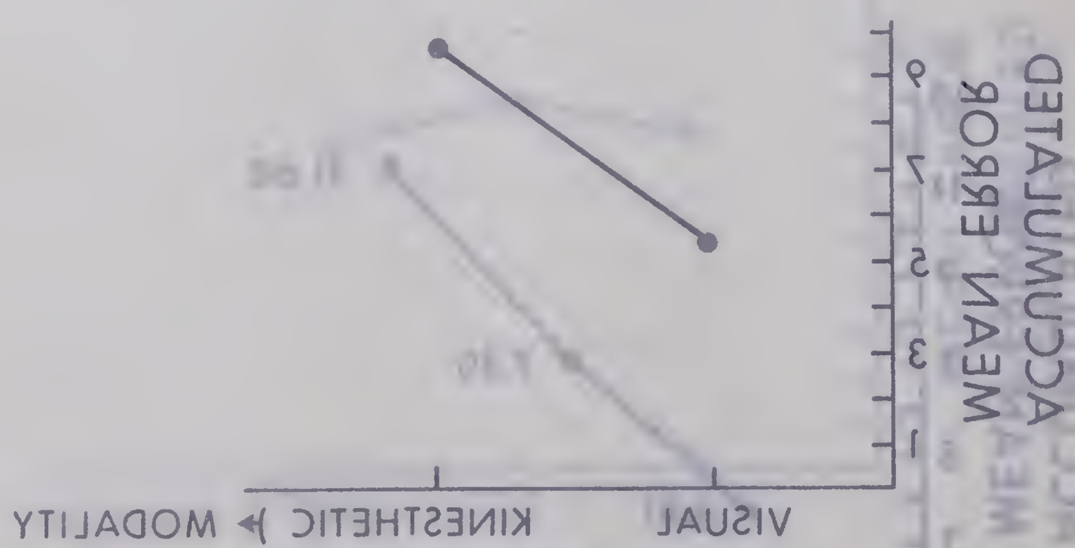


FIGURE 3

SENSORY MODALITY vs MEAN ERROR





trials (condition means) were utilized for each level. Both levels of sensory modality are represented by nine trials. The bottom graphs illustrate the accumulated means for each factor. In all cases, the means were graphed in a predetermined order. The visual trials were all plotted to the left of the kinesthetic trials.

The primary main effects for visual and kinesthetic performance are illustrated in Figure 4. Each point on the graph represents three condition means. On all levels of short-term memory, visual retention is the more accurate. From the graph no significant difference is in evidence between immediate and delayed recall on either the visual or kinesthetic level. However, both immediate and delayed recall appear significantly different from delay plus interpolated recall. This finding was verified by a Duncan's New Multiple Range Test (Tables 1X and X). No statistical significant difference existed between immediate and delayed recall (α = .01) with respect to either visual or kinesthetic retention. However, in both visual and kinesthetic retention, the delay plus interpolated condition was significantly different and greater than either immediate or delayed recall.

Discussion

In the field of short-term memory it is generally accepted that visual and verbal sensory material decay rapidly over a time interval (65, 32, 54, 34). In addition, Adams and Dijkstra (1:317) and Posner and Konick (75:76) have found basically the same results when a motor task was utilized. The main effects of this experiment support both of the previously mentioned concepts. A significant difference was found

FIGURE 4

MEAN ERROR vs VISUAL AND KINESTHETIC SHORT-TERM MEMORY (PRIMARY MAIN EFFECTS)

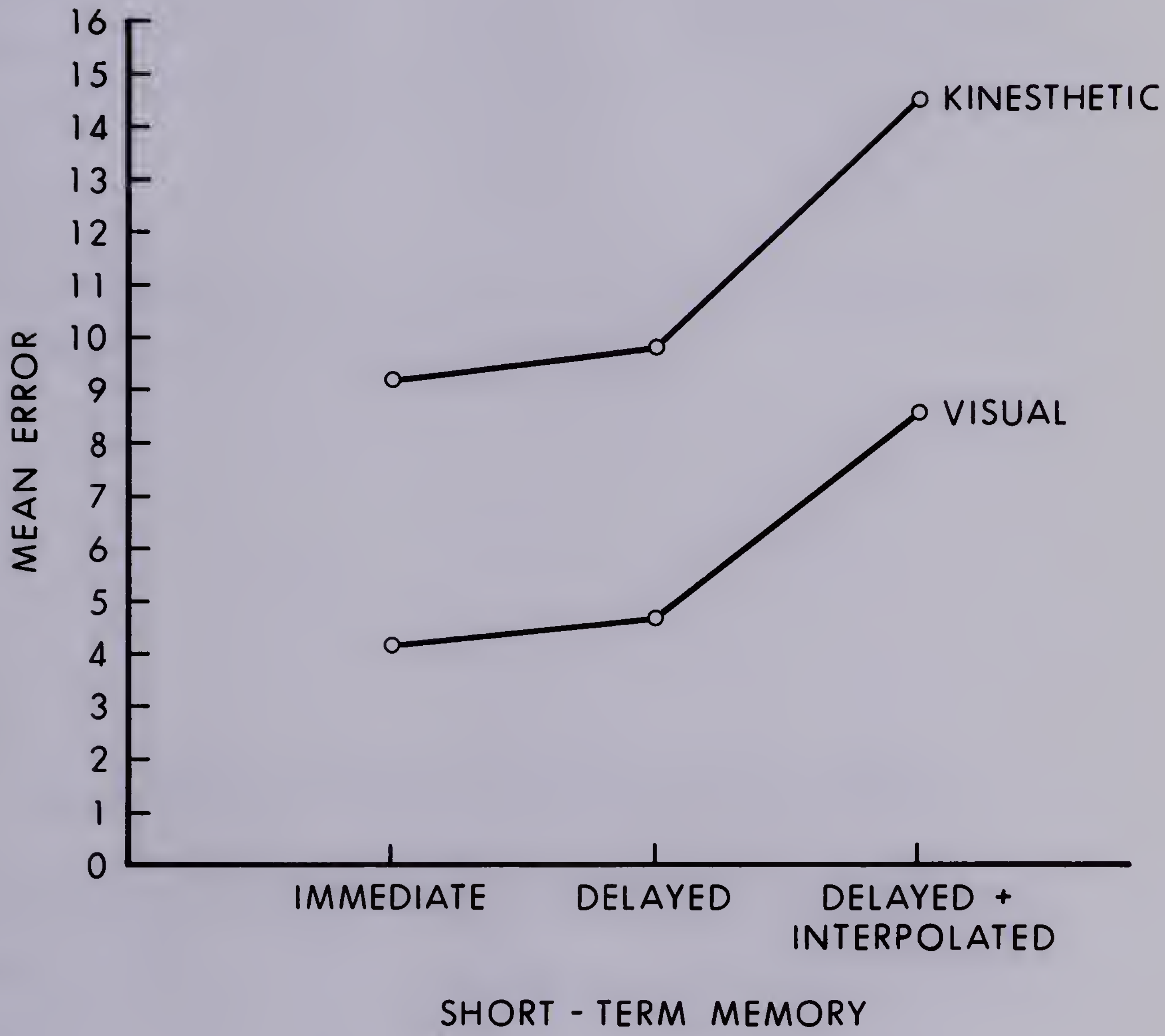


FIGURE 4

MEAN ERROR vs VISUAL AND KINESTHETIC SHORT-TERM MEMORY (PRIMARY MAIN EFFECTS)

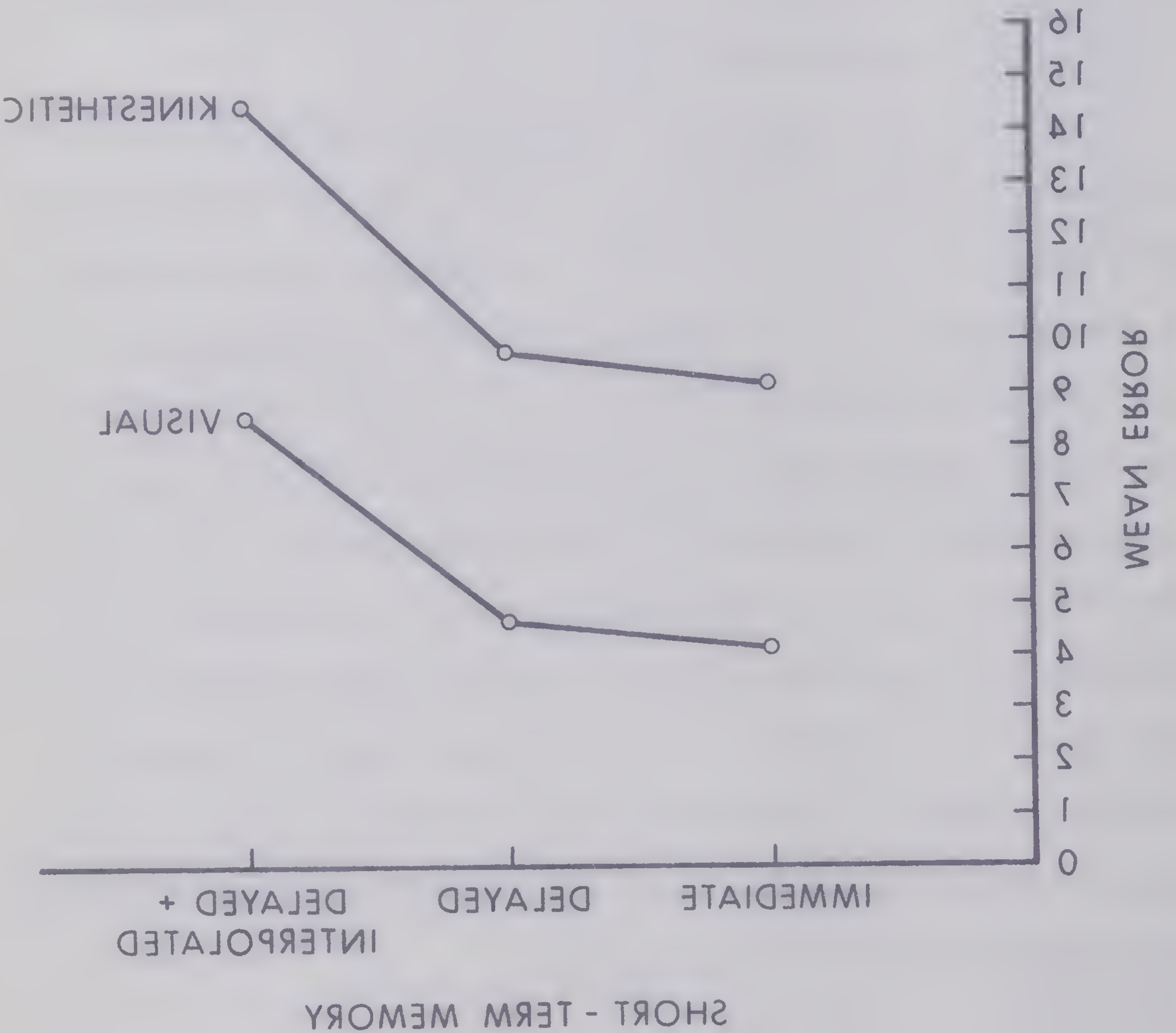


Table 1X

DUNCAN'S NEW MULTIPLE RANGE TEST K = 3 MEANS
ON PRIMARY MAIN EFFECTS (VISUAL SHORT-TERM MEMORY)

Means	4.07 I	4.75 D	8.69 D + INT	Shortest significant R
4.07		.68	4.62*	$R_2 = 2.99$
4.75			3.94*	$R_3 = 3.11$
8.69				

* Significant at .01 level of confidence.

Table X

DUNCAN'S NEW MULTIPLE RANGE TEST K = 3 MEANS
ON PRIMARY MAIN EFFECTS (KINESTHETIC SHORT-TERM MEMORY)

Means	9.07 I	9.91 D	14.51 D + INT	Shortest significant R
9.07		.84	5.44*	$R_2 = 2.99$
9.91			4.60*	$R_3 = 3.11$
14.51				

* Significant at .01 level of confidence.

between immediate and delayed recall (α = .01). Furthermore, when an interpolated task of ten seconds duration was interjected between presentation and recall, the resulting error score was significantly different and greater than both the immediate and the delayed situations.

The primary main effects (Figure 4) are similar to the experimental findings of Posner and Konick (74) and to a theory postulated by Broadbent (9:241). In the former case, Posner and Konick have suggested that when short-term memory is plotted against mean error, the difference between immediate and delayed retention is insignificant. Furthermore, the effect of the interpolated task was of such magnitude that a significant difference in mean error occurred when the interpolated condition was compared with either immediate or delayed retention. The same conclusions can be derived from Tables 1X and X. There is in fact relatively little difference between immediate and delayed retention when the primary main effects are concerned. On the other hand, a significant difference occurs when immediate or delayed recall is compared either to visual or kinesthetic delay plus an interpolated task. Broadbent (9:241) concluded that in visual and verbal tasks forgetting is rapid with the greatest amount occurring within the first three seconds. As previously stated, when primary main effects are concerned, this does not appear to be the case. In fact between immediate and delayed recall there were discrepancies of only .84 and .68 of a degree for the kinesthetic and the visual situations respectively. Thus, the results of this experiment do not support Broadbent's theory for visual and verbal tasks. However, Broadbent (9:241) also hypothesized that the rapid forgetting should not be as marked in motor skills as they were less

appropriate to a recurrent circuit mechanism. When a free-moving-load system was used, rapid forgetting was not observed between immediate and delayed retention in the primary main effects. Thus, the results of this experiment are similar to those normally found for motor tasks but different than the current findings for visual and verbal task.

Posner and Konick (75:76) and Broadbent (9:241) have concluded that kinesthetic retention should be less effected than visual retention in the presence of an interpolated task. When an interpolated task is not present, visual retention should be more accurate than kinesthetic retention. Basically, they both support the concept that this difference occurs because visual and kinesthetic sensations are processed in a different manner. From the findings of their experiments it would appear that visual material is accepted by a central processing mechanism while kinesthetic sensations are not. In this respect, interpolated material would either overload the central system or simply confuse the rehearsal of the primary sensory material. The results obtained in this study are in agreement with these concepts only partially. Within the confines of this experiment it did appear that visual retention was more accurate than kinesthetic retention in the absence of an interpolated task. This conclusion was evident with respect to both main effects and primary main effects. However, in the presence of an interpolated task, visual retention remained superior to kinesthetic retention. The previously mentioned conclusions achieved by Posner were the result of a series of interpolated tasks of graded difficulty. In Posner and Konick's report (75) they stated that kinesthetic retention was superior to visual retention in the presence of a difficult interpolated task. This statement

leads the experimenter to the logical conclusion that perhaps the interpolated task (simple addition) used in the present experiment was not difficult enough to cause the disruption of visual memory storage. Basically, the interpolated task did cause serious reduction in accuracy of recall. This result is generally found in visual, verbal, or motor tasks (1, 5, 48, 66, 75). However, the conclusions derived in the present situation are not similar to the findings of Pylyshyn (78) who found only a small decrement in retention with an interpolated task.

The concept of utilizing a free-moving-load system to illustrate the general principles of short-term memory is a new one. Thus, no prior hypothesis (except the null) was formed with respect to the ballistics quality of the apparatus. In this experiment the null hypothesis was accepted. No significant difference in replacement accuracy occurred between the low, medium, or high ballistics conditions. The three ballistics conditions were 1.5" X 5 lbs., 3.0" X 5 lbs., and 6.0" X 5 lbs. for low, medium, and high respectively. There could be two possible reasons why no significance in replacement accuracy occurred. It could be the case that the different weight qualities were not large enough to leave a significant impression on the memory system. On the other hand, perhaps the difference between the three ballistics qualities were not perceptually different enough in a system of this type. If the latter were true then the kinesthetic memory system would treat all qualities as being equal. This is what did occur but at present insufficient evidence is available to discern the exact reasoning behind the phenomenon.

At the conclusion of each subject's testing period it was the intent

of the experimenter to question the subjects. The motive behind this series of questions was the discovery of the methods used by the subjects to store material. The answers obtained were in agreement with those usually received when subjects are employed in a motor task (1, 6, 5, 75). Without exception all subjects reported the utilization of a circular clock-like image to facilitate recall. This supports the theory that primary retention of information is through imagery rather than through verbal codes.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to discern which of the available sources of sensory input a performer attends to in perceptual-motor tasks. In particular, the area of interest was confined within a free-moving-load system category. The specific problems of the study were as follows:

1. To assess the relative importance of both visual and kinesthetic short-term memory in tasks involving the intertial qualities of skilled movement.

2. To determine whether both visually and kinesthetically stored short-term memory are retained equally and whether both are equally effected by an interpolated task.

3. To determine the effect which a change in ballistics pressure has on the accuracy of short-term retention.

Toward these ends, three null hypotheses were formed. The first hypothesis stated that no statistically significant difference existed between immediate and delayed recall but both of these were significantly smaller than the delay plus an interpolated condition. The second hypothesis stated that visual short-term retention was superior to kinesthetic retention, except in the presence of an interpolated task where the reverse was true. The final hypothesis supported the theory that there was no statistically significant difference between the three

ballistics pressures.

The experimental group consisted of nine randomly selected right-handed subjects. Each subject was presented with the eighteen experimental conditions (five replications) in a randomly selected order. Over the process of the experiment each subject received ninety trials.

Conclusions

Conclusions can only be derived within the limitations of the sample tested and the reliability of the experimental procedures employed. With this concept in mind the following conclusions were formulated.

People do not appear to attend to ballistics pressure of the calibre utilized in this experiment. This conclusion is justified by the statistical insignificance which ballistics pressure illustrated when compared to the accuracy of short-term retention. The change in ballistics pressure had no effect on short-term retention.

Motor tasks are processed in a different fashion than visual or verbal tasks. It is a normally accepted fact that visual and verbal short-term memory decays exponentially over time and is significantly effected by the presence of an interpolated task. In fact, in motor tasks, if concern is only with main effects then this does occur. However, when primary main effects are considered, no statistically significant loss of retention occurs over a ten second delay period. Retention of motor tasks is similar to visual and verbal retention in the respect that an interpolated task causes a significant degree of forgetting. However, contrary to results found by Posner (75), visual retention of motor tasks remained superior to kinesthetic retention. A

usually accepted fact in visual and verbal short-term retention is the utilization of verbal cues to facilitate recall (66, 67, 36, 50). In this study, verbal cuing was not in evidence. The subjects utilized visual images to increase accuracy of recall. This is similar to the conclusion achieved by Posner in a study which contained a motor task (75). Thus, it appears that motor tasks are not processed in a similar fashion to visual and verbal tasks.

Further Direction

Relatively little concentration has been done on tasks involving weight or torque change. Prior to this experiment, no study has been conducted which used a free-moving-load system as an apparatus. In this respect, the selection of the quantity of ballistics pressure used was experimentally selected. At this time it is not known if larger weights or a greater discrepancy between the individual weights would have an effect on short-term retention. Perhaps the kinesthetic system only functions above a certain weight level. An experiment involving larger weights would be valuable for if a weight plateau does exist then attention must be given to it. On the other hand, if a plateau does not exist then individuals are wasting their efforts by trying to train the kinesthetic sense.

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APPENDICES

APPENDIX A

TREATMENT CONDITIONS IN ORDER

OF PRESENTATION TO THE COMPUTER

TREATMENT CONDITIONS IN ORDER OF PRESENTATION TO COMPUTER

Short-term memory 3	Ballistics quality 3	Modality 2	Condition No.
Immediate	1.5" X 5 lbs.	Visual	16
Delay	1.5" X 5 lbs.	Visual	18
Interpolated	1.5" X 5 lbs.	Visual	05
Immediate	3.0" X 5 lbs.	Visual	13
Delay	3.0" X 5 lbs.	Visual	02
Interpolated	3.0" X 5 lbs.	Visual	10
Immediate	6.0" X 5 lbs.	Visual	12
Delay	6.0" X 5 lbs.	Visual	08
Interpolated	6.0" X 5 lbs.	Visual	09
Immediate	1.5" X 5 lbs.	Kinesthetic	17
Delay	1.5" X 5 lbs.	Kinesthetic	11
Interpolated	1.5" X 5 lbs.	Kinesthetic	07
Immediate	3.0" X 5 lbs.	Kinesthetic	01
Delay	3.0" X 5 lbs.	Kinesthetic	14
Interpolated	3.0" X 5 lbs.	Kinesthetic	06
Immediate	6.0" X 5 lbs.	Kinesthetic	15
Delay	6.0" X 5 lbs.	Kinesthetic	03
Interpolated	6.0" X 5 lbs.	Kinesthetic	04

APPENDIX B

TESTS FOR RIGHT-HANDEDNESS

TESTS FOR RIGHT HANDEDNESS

A battery of tests was administered to the subjects as a means of ensuring dominant right handedness. Tests were performed involving eyes, hands, and feet. It was assumed that if a subject was dominantly left or right in these three categories then he could be considered completely left or right handed. The tests are as follows:

Eye Tests There were two eye tests. The first test simply required the aiming of a gun by the subjects. It was assumed that the dominant eye would be utilized during the aiming procedure. The second test involved the observation of objects through an exceptionally small aperture. Once again it was assumed that the dominant eye would be used for fine observation.

Hand Tests There were also two tests for hand dominance. The first test required the subjects to write their signatures. In the second test the subjects were required to pick up tiny objects placed in close proximity to other objects. This second test involved intricate manipulation of the hands.

Leg Tests The test for the selection of the dominant leg was one where the criterion was kicking a soccer ball for accuracy. The subjects had to kick this ball, a distance of twenty feet, through two upright pegs placed on the ground.

Only those subjects who passed every test successfully were used in the study. It was believed that these subjects could be considered predominantly right handed.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

APPENDIX C

INTERPOLATED TASK

3	6	9	7	2	6	9	8	4	9	5	7	2
0	3	2	8	9	5	3	7	0	4	7	1	5
4	6	3	0	9	4	2	8	1	2	3	5	1
1	8	3	1	5	9	2	6	5	7	0	2	9
7	1	6	8	3	9	0	8	9	4	8	5	2
2	3	1	8	9	8	5	1	2	5	3	6	1
2	6	3	1	1	9	8	0	3	4	1	4	8
5	6	7	5	8	3	5	3	4	5	0	8	2
9	7	0	1	2	6	7	8	3	8	0	9	2
5	9	6	9	1	0	8	4	5	6	9	1	0
7	4	0	6	5	5	4	1	5	6	9	5	1
3	8	8	0	4	1	3	6	2	3	1	7	8
1	3	8	3	9	1	2	5	9	2	7	5	8
1	6	9	7	2	8	3	4	7	1	9	4	2
7	2	4	6	3	6	7	3	8	4	1	2	0
2	3	2	4	5	0	6	4	9	5	3	2	5
5	7	5	1	5	3	7	8	3	6	9	0	2
2	6	3	1	8	9	8	0	3	4	1	4	8
9	6	8	4	7	5	6	1	3	6	9	6	0
3	0	9	1	6	4	8	5	2	4	8	9	1

3	6	6	2	2	6	3	8	3	5	9	5	4
9	5	7	3	1	1	8	2	3	9	7	9	4
0	3	7	5	2	6	0	6	9	6	4	3	1
7	3	6	5	6	5	4	8	2	7	8	4	9
2	2	3	0	6	2	5	8	1	5	3	2	6
0	5	6	1	6	3	8	9	8	9	1	9	5
3	7	0	5	5	4	7	2	7	4	9	3	6
4	7	9	6	9	2	9	1	1	8	1	3	8
9	5	9	4	6	3	6	5	3	7	2	4	1
9	4	2	5	4	0	6	4	7	3	8	5	2
5	9	2	0	9	8	7	6	8	8	9	2	3
3	7	3	2	8	1	4	8	1	6	6	4	5
7	1	0	9	8	0	9	4	2	1	3	1	7
1	8	6	8	5	6	2	0	5	5	3	1	0
1	0	8	9	6	2	6	5	6	4	9	8	2
8	7	6	5	3	3	4	2	1	9	8	4	2
8	3	7	9	2	0	7	4	9	1	7	8	4
8	0	5	6	0	9	2	5	7	4	9	4	3
6	6	5	0	3	6	2	5	6	7	3	3	4
4	9	4	7	5	2	9	5	3	2	8	7	0

7	0	6	5	1	6	5	1	9	6	1	5	0
4	6	5	1	6	9	1	8	6	1	5	4	3
5	9	6	1	0	8	4	5	9	1	2	8	0
9	7	1	2	6	7	3	4	9	6	8	4	6
1	3	8	9	1	2	5	9	7	4	8	8	2
7	3	2	8	5	1	8	3	4	2	1	2	5
3	0	4	1	7	2	2	5	9	5	7	3	1
1	2	9	5	3	0	1	6	2	1	2	3	6
5	7	4	9	4	3	8	3	7	6	5	2	6
6	6	2	0	4	7	9	1	8	7	4	8	2
5	2	7	4	1	6	4	3	9	6	1	4	5
2	4	6	5	3	9	7	0	5	8	6	2	9
2	1	0	5	8	6	7	4	9	0	5	4	8
7	9	2	3	4	8	6	9	3	5	2	9	3
2	4	6	7	4	8	0	6	8	4	3	8	4
5	6	2	5	8	9	3	4	8	3	6	4	2
2	4	6	8	7	4	6	0	6	0	2	8	3
0	2	9	3	5	4	6	8	7	9	4	3	7
3	9	6	4	7	5	2	8	3	5	9	4	6
2	3	4	5	7	6	0	7	9	4	2	4	3